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BEST MANAGEMENT PRACTICES

MOTOR VEHICLE PARTS MANUFACTURING SECTOR:

CADMIUM AND NONYLPHENOL AND ITS ETHOXYLATES

Prepared for:

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This Best Management Practices (BMPs) document has been prepared by a consultant team headed by XCG Consultants Ltd. (XCG) to describe various BMP activities available through literature review and through application of the consultant's knowledge and professional opinion of potential BMP approaches to achieve pollution prevention and a reduction of specific contaminants that may be present in effluent discharges from selected industrial, institutional and commercial (IC&I) facilities. The document also outlines preliminary opinions of estimated costs for BMP implementation and of additional treatment processes that may be required to further reduce and/or remove specific contaminants as a function of effluent reference discharge criteria.

The document provides qualitative and quantitative estimates of potential reductions achievable through pollution prevention and treatment measures for specific pollutants and is intended to be a 'guidance' document only. Site-specific analysis of each facility is required to identify the most effective pollution prevention and treatment measures.

The document does not reflect the official position or the views of the Government of Ontario or the Ministry of the Environment.

EXECUTIVE SUMMARY

The Best Management Practices (BMPs) document for the Motor Vehicle Parts Manufacturing Sector is one in a series of documents to identify BMPs to eliminate or reduce specific harmful pollutants potentially found in wastewater effluents of six industrial sectors in Ontario. These documents provide qualitative and quantitative estimates of the potential reductions achievable through pollution prevention and treatment measures for specific pollutants of concern. This BMP document is a guide only; site-specific analysis of each facility is required to identify the most effective pollution prevention and treatment measures.

This document identifies BMPs to eliminate or reduce cadmium and nonylphenol and its ethoxylates (NPE) in wastewater effluents of the motor vehicle parts manufacturing sector. The two primary audiences for this document are municipal representatives and industrial facility representatives. Specific sub-sectors within the motor vehicle parts manufacturing sector addressed include Motor Vehicle Gasoline Engine and Engine Parts Manufacturing (NAICS[1] 33631); Motor Vehicle Electrical and Electronic Equipment Manufacturing (NAICS 33632); Motor Vehicle Metal Stamping (NAICS 33637) Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing (NAICS 33633); Motor Vehicle Brake System Manufacturing (NAICS 33634); and Motor Vehicle Transmission and Power Train Parts Manufacturing (NAICS 33635).

Benefits of implementing BMPs, specifically pollution prevention measures, include but are not limited to, the following:

- Increased cost-effectiveness and lower long-term costs;
- Increased customer satisfaction;
- Social benefits, such as good community relations;
- Reductions in energy, water and materials used; and
- Reduced risk and liability.

In the motor vehicle parts manufacturing sector, NPE are used in solvents for surface preparation, metal processing, and in water based paints for metal coating. In the motor vehicle parts manufacturing sector, cadmium can enter wastewater through the processes of metal shaping and metal cutting when metal working fluids are used, metal plating operations in bath and rinse water, and possibly cleaning and surface preparation.

In developing the BMP guidance documents, three reference criteria were considered with respect to final effluent concentrations for harmful substances. The three reference criteria are identified in Table ES.1. Reference Criteria 1 are the most stringent and Reference Criteria 3 are the least stringent. Due to the methodology applied to develop the reference criteria, as elaborated within the main text, two of the three reference criteria are the same in some instances.

[1] North American Industry Classification System (NAICS) used by Statistics Canada.

Table ES.1 Reference Criteria for Substances in the Motor Vehicle Parts Manufacturing Sector

Substance	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Cadmium	0.0006	0.02	1
Nonylphenol	0.001	0.001	0.0025
Nonylphenol Ethoxylates	0.001	0.01	0.025

BMPs are described in this document in four categories: elimination and reduction; operating and housekeeping; education and training; and treatment. The first three categories are considered pollution prevention (P2) measures; treatment is not. Pollution prevention (P2) is defined as "the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste, and reduce the overall risk to the environment or human health."[2] P2 measures are more effective than treatment in reducing releases of hazardous substances and should, therefore, be implemented in preference to treatment to meet release reference criteria. Multiple P2 measures can be implemented concurrently.

Table ES.2 identifies the pollution prevention BMPs described in this document.

Table ES.2 Summary of P2 Measures

Substance Addressed	BMP Name	BMP Number
	Elimination/ Reduction	All Sub-Sectors
NPE & Cadmium	Maximize the use of recycled water	BMP #1
NPE & Cadmium	Process fluid waste minimization	BMP #2
NPE & Cadmium	Reduce waste from spray-painting	BMP #3
NPE & Cadmium	Reduce drag-out loss in metal plating operations	BMP #4
NPE & Cadmium	Drag-out return recovery technologies for metal plating operations	BMP #5
NPE & Cadmium	Rinsewater reductions for metal plating operations	BMP #6
Cadmium	Solder substitution	BMP #7
Cadmium	Material substitution for cadmium plating	BMP #8
Cadmium	Air cooling as a replacement for cooling oils	BMP #9
Cadmium	Alternative deposition methods	BMP #10
NPE	Material substitution for NPE containing products	BMP #11
NPE	Material substitution for NPE containing cleaning and surface preparation products	BMP #12

[2] Definition in Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the *Canadian Environmental Protection Act*, 1999 (CEPA 1999), National Office of Pollution Prevention, Environment Canada, 2001

Table ES.2 (cont'd) Summary of P2 Measures

Substance Addressed	BMP Name	BMP Number
Operating Procedures and Housekeeping		All Sub-Sectors
NPE & Cadmium	Contain all above-ground tanks containing liquids, whose spillage could be harmful to the environment	BMP #13
NPE & Cadmium	Effective operational and maintenance systems	BMP #14
NPE	Maintain optimum concentration range for NPE containing metal processing products	BMP #15
NPE	Maintain optimum concentration range for etching baths containing NPE	BMP #16
NPE & Cadmium	Accident prevention	BMP #17
Education and Training		All Sub-Sectors
NPE & Cadmium	Management and staff training	BMP #18

To achieve the three reference criteria (Table ES.1), the most effective and appropriate combinations of P2 BMPs and treatment processes were identified. These combinations were selected on the basis of ability to achieve the reference criteria, costs, and feasibility for implementation, using estimates and engineering judgment. Table ES.3 provides an overview of the estimated effectiveness of the select P2 BMPs identified. Refer to the Tables in Section 5 for details of combinations of P2 and treatment BMPs identified.

Table ES.3 Summary of Effectiveness of BMPs

Substance Addressed	BMP Name	BMP Number
Elimination/ Reduction Effectiveness: 50-75%		
Cadmium	Drag-out reduction	BMP #4
Cadmium	Material Substitution for cadmium plating	BMP #8
NPE	Material Substitution for NPE containing cleaning products	BMP#11
NPE	Material Substitution for NPE containing surface preparations and metal processing products	BMP #12
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
Cadmium & NPE	Contain all above-ground tanks containing liquids whose spillage could be harmful to the environment	BMP #13
Cadmium & NPE	Effective operational and maintenance systems	BMP #14
Cadmium & NPE	Accident prevention	BMP #17
Education & Training Effectiveness: 5 % for Cadmium, 2 % for NPE		
Cadmium & NPE	Management and staff training	BMP #18

Based on the estimated initial concentrations and percent removal resulting from implementation of P2 measures, all substances require some level of treatment after P2 implementation in order to meet the reference criteria.

Assuming a chemical precipitation system is already in place for metals pre-treatment and assuming P2 measures can reduce all substances outlined in this sector as detailed in this BMP document, additional treatment after chemical precipitation is required for cadmium to meet Reference Criteria 1 and 2. For nonylphenol and nonylphenol ethoxylates (NPE), additional treatment is required to meet all reference criteria (unless aggressive elimination of all NPE sources is undertaken).

Combinations of P2 measures and treatment processes needed to achieve the three reference criteria (Table ES.1) were developed using estimates and engineering judgment. The following were developed and considered:

- Estimated cost ranges for capital and operating costs.
- Cost estimates for implementation of pollution prevention (P2) measures were based on the number of persons employed at the facility, which was used to estimate percent of operating budget required for implementation.
- Cost estimates for treatment systems were based on a range of wastewater flow rates assumed for the sector. Based on typical wastewater data for this sector and the estimated reductions with P2 measures, granular activated carbon (GAC) followed by reverse osmosis (RO) can reduce the level of NPE to the required concentrations to meet Reference Criteria 1, and GAC alone can reduce the level of NPE to the required concentrations to meet Reference Criteria 2 and 3. In the case of cadmium, treatment by deionization (DI) after chemical precipitation is required to meet the concentrations defined by Reference Criteria 1 and 2. Chemical precipitation is the only level of treatment required after P2 measures to achieve the Reference Criteria 3 requirements for cadmium.

Table ES.4 provides a summary of estimated costs for selected P2 BMPs and Table ES.5 provides a summary of estimated costs for possible treatment systems needed after P2 implementation to achieve the Reference Criteria requirements.

Table ES.4 Estimated Pollution Prevention Costs (for selected P2 BMPs)

Type of P2 Measure	Pollution Prevention Annual Costs*		
	Small Facilities (25 Staff)	**Medium Facilities (175 Staff)**	**Large Facilities (300 staff)**
Pollution Elimination or Reduction	$16,300	$17,305	$19,200
Operating/ Housekeeping	$20,000	$160,000	$270,000
Education/Training	$8,000	$65,000	$110,000
Total Estimate	$44,300	$242,305	$399,200

Note:
* Estimated annual costs for each P2 measure are approximation only; facility specific wastewater quality and operating practices must be assessed prior to selection of P2 practices.

Note that estimates are dependent on the incoming concentrations of NPE and cadmium prior to P2 measures, and concentrations achieved after P2 measures. Thus, site-specific wastewater testing is necessary at all facilities to determine compliance with regulations and to implement appropriate measures.

Based on the estimated wastewater concentrations of cadmium and NPE after P2 measures and an assumption that the BOD_5 is less than 100 mg/L[3], the overall full treatment systems for each reference criteria are as follows:

- Reference Criteria 1: chemical precipitation, sand/mixed media filtration, GAC, microfiltration, RO, and DI;
- Reference Criteria 2: chemical precipitation, sand/mixed media filtration, GAC, microfiltration, and DI; and
- Reference Criteria 3: chemical precipitation, sand/mixed media filtration, and GAC.

Capital and operational and maintenance (O&M) cost curves were developed for the full treatment requirements for the motor vehicles parts manufacturing sector, as above indicated, for all identified substances in order to meet the three reference criteria using a wastewater flow range of 1 m^3/h to 50 m^3/h. Estimated capital treatment costs ranged from $70,000 to $4.0 million, and O&M costs ranged from $10,000 to $400,000. Reductions in treatment costs may be achieved through aggressive P2 measures: cost reductions of 25 to 65% through the elimination of cadmium and cost reductions of 10 to 60% through the elimination of NPE may be achieved.

Costs were also developed for an alternative treatment scenario where cadmium is significantly reduced or eliminated through P2 measures to sufficiently low levels whereby DI would not be required for Reference Criteria 1 and 2. Table ES.5 includes this alternative treatment scenario.

[3] Should BOD_5 concentrations after P2 measures but before treatment be higher than 100 mg/L, additional treatment, such as biological treatment for NPE removal, may be required.

Table ES.5 Estimated Capital and Annual Operation and Maintenance Costs

Reference Criteria	**Approximate Costs as Function of Flow Range of 1 to 50 m^3/h**					
	Capital Cost Range			**Annual O&M Cost Range**		
	1m^3/h	**25 m^3/h**	**50 m^3/h**	**1m^3/h**	**25 m^3/h**	**50 m^3/h**
Full Treatment						
Criteria 1	$302,000	$2,484,000	$4,060,000	$45,000	$298,000	$406,000
Criteria 2	$258,000	$1,173,000	$2,101,000	$39,000	$141,000	$210,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Treatment Assuming Low Cadmium Levels (i.e., no DI)						
Criteria 1	$127,000	$1,772,000	$2,777,000	$19,000	$213,000	$278,000
Criteria 2	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000

Note:
Costs exclude chemical precipitation (metals removal), which is assumed to be installed. If required, the following estimated capital costs should be added: 1 m^3/hr = $67,200; 25 m^3/hr = $371,000; 50 m^3/hr = $658,000. The corresponding annual operations and maintenance (O&M) costs for a chemical precipitation system are $10,000, $45,000 and $66,000 respectively for system sizes of 1 m^3/hr, 25 m^3/hr and 50 m^3/hr.

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APPENDICES

Appendix A Best Management Practices Documents

Appendix B Sub-Sector Definitions

Appendix C Agreements for Toxic Reduction and Substances of Concern

Appendix D Case Study Examples Demonstrating Benefits of P2 Measures

1. OVERVIEW OF THIS DOCUMENT

1.1 Objective and Audience

This document identifies best management practices (BMPs) to eliminate or reduce cadmium and nonylphenol and its ethoxylates (NPE) in wastewater effluents of the motor vehicle parts manufacturing sector. The benefits of undertaking BMPs are also described. This BMP document is a guide only; site-specific analysis of each facility is required to identify the most effective pollution prevention and treatment measures.

This document is one in a series of documents to identify BMPs to eliminate or reduce specific harmful pollutants potentially found in wastewater effluents of six key industrial sectors in Ontario. Appendix A identifies the other industrial sectors and substances for which similar BMP documents have been developed.

The two primary audiences for this document are:

- **Municipal representatives** interested in assisting industrial facilities with sewer discharges to eliminate or reduce harmful pollutants.
- **Industrial facility representatives** interested in implementing BMPs to eliminate or reduce harmful pollutants and to increase company reputation for implementing 'green policies', specifically operations staff and management staff.

Specific sub-sectors within the motor vehicle parts manufacturing sector addressed within this document include:

- Motor Vehicle Gasoline Engine and Engine Parts Manufacturing (NAICS[4] 33631);
- Motor Vehicle Electrical and Electronic Equipment Manufacturing (NAICS 33632);
- Motor Vehicle Metal Stamping (NAICS 33637);
- Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing (NAICS 33633);
- Motor Vehicle Brake System Manufacturing (NAICS 33634); and

[4] North American Industry Classification System (NAICS) used by Statistics Canada. The NAICS is an industry classification system developed by the statistical agencies of Canada, Mexico and the United States. Created against the background of the North American Free Trade Agreement, it is designed to provide common definitions of the industrial structure of the three countries and a common statistical framework to facilitate the analysis of the three economies. http://www.statcan.ca/english/Subjects/Standard/naics/2002/naics02-intro.htm (accessed December 20, 2005)

- Motor Vehicle Transmission and Power Train Parts Manufacturing (NAICS 33635).

Definitions for these sub-sectors are provided in Appendix B .

The harmful pollutants addressed in this series of BMP documents have been identified at both the federal and provincial government levels, as part of on-going initiatives to limit the effect of wastewater discharges on receiving waters. Appendix C provides a list of agreements and programs, as well as substances identified by the Ontario Ministry of the Environment (MOE) to be of particular concern under these or other initiatives.

1.2 Benefits of Implementing Pollution Prevention

In addition to reductions in pollutants released to water, air, and soil, implementation of pollution prevention best management practices and high quality environmental performance has numerous benefits, including:

- Increased cost-effectiveness and lower long-term costs through implementation of pollution prevention measures in a planned, holistic manner;
- Increased customer satisfaction through meeting expectations for goods and services to be produced in an environmentally responsible manner;
- Social benefits, such as good community relations and potential endorsement of facility efforts and activities;
- Reductions in energy, water, and materials used, with associated operating cost savings;
- Compliance with federal and municipal regulations;
- Reduced risk and liability resulting from regulatory non-compliance, spills, and environmental emergencies;
- Increased innovation through process and materials improvements and supply chain communication;
- Better return on investment for shareholders;
- Health and safety benefits through reduced worker exposure; and
- Higher public approval ratings and improved corporate reputation.

A study of the relationship between environmental performance and financial performance,[5] using the Standard & Poor's 500 Index (S&P 500), compared the financial performance of "low polluter" portfolios to industry-matched "high polluter" portfolios. The study found that the "low polluter" portfolio performed as well as - and often better than - the "high polluter" group. Investors who chose the environmental leaders in an industry-balanced portfolio were found to do as well (or better) than those choosing the environmental laggards in each industry. According to the study, a portfolio that tracked the S&P 500 and included only the environmental leaders in each industry category would be expected to meet or exceed the market returns of the S&P 500. The study concluded that greener firms are performing as well as or better than their more polluting counterparts.

Literature references on pollution prevention do not generally quantify benefits and cost savings resulting from implementation of P2 measures. Individual case studies, however, often do identify cost savings and benefits. Refer to Appendix D, Case Study Examples Demonstrating Benefits of P2 Measures for case studies of facilities that have documented the benefits of implementing P2 measures while, at the same time, reducing releases of hazardous substances.

1.3 Methodology

This BMP documents was developed by a consultant team with the advice of a Steering Committee of provincial and municipal representatives. A detailed review of literature was conducted by the consultant team to identify available information on specific substance–sector combinations. Sector specialists and other representatives identified through the literature review were contacted for additional information and to obtain recent data, where available. Engineering estimates and consultant team expertise also supported the analysis and development of the BMP documents.

A number of estimating procedures or assumptions were made to support the development of options and costs for both the pollution prevention and the treatment measures. These estimating procedures were developed through available data and consultant team expertise. Refer to Sections 3 and 4 for brief outlines of the estimating procedures made for pollution prevention and treatment effectiveness and costs.

1.4 How to Use This Document

In addition to this introductory section, this BMP document consists of the following sections:

[5] Environmental and Financial Performance: Are They Related? M. A. Cohen, S. A. Fenn, S. Konar, Vanderbilt University, Nashville, TN, 1997 (URL) http://sitemason.vanderbilt.edu/files/d/dLwFkQ/Environmental%20and%20Financial%20Performance.pdf, (accessed January 2006)

- **Section 2, Background**, provides information on the use of substances of interest in the sector, reference criteria targets used to analyze and develop the BMPs and reporting requirements for the substances.

- **Section 3, Pollution Prevention**, identifies pollution prevention (P2) options, including operating, housekeeping, training and education opportunities and suggestions. Identifies specific combinations of P2 practices, including estimates of implementation costs.

- **Section 4, Treatment**, identifies the specific combinations of treatment (assuming the combinations of P2 measures identified in Section 3 are implemented) to achieve the three reference criteria levels, including underlying assumptions for the reduction analyses.

- **Section 5, Options for Reduction of Substance concentrations in Effluents,** summary tables of the P2 and treatment measures identified in Sections 3 and 4.

- **Section 6, References**, identifies key reference documents used in the development of this BMP document.

- **Section 7, Glossary**, defines terminology and acronyms used in the document.

- **Appendices** provide information on other documents in this series, sector definitions, a list of harmful substances of particular interest, and case studies.

Once having read this document, practitioners are encouraged to:

- Assess the concentration of identified substances in the effluent of their facility versus the three reference criteria analyzed (Section 2.2).

- Identify potential sources of these substances in their effluent and assess P2 and treatment options, as well as broader management practices (Sections 3 and 4).

- Review the estimating procedures and assumptions stated in Sections 3 and 4 and information presented in the Tables of Section 5 for an indication of measures that could potentially be implemented to meet the target reference criteria.

- Refer to municipal by-laws or other requirements applicable to the facility with respect to control requirements for the substances.

2. BACKGROUND

2.1 Use of the Substances of Interest in this Sector

For the purposes of assessing the effectiveness of pollution prevention measures and treatment technologies, representative raw wastewater concentrations of the substances addressed in this document have been estimated as summarized in Table 2.1. An extensive literature review for raw wastewater concentrations and characteristics specific for the motor vehicle parts manufacturing sector did not produce significant characterization results. Rather, reviewed data from other industrial sectors, in particular for the chemical manufacturing and the fabricated metal products sectors, as deemed appropriate, were used to estimate representative wastewater concentrations for cadmium, nonylphenol and its ethoxylates. It should be noted that due to the diversity of fabrication and manufacturing operations in the motor vehicle parts manufacturing sector, concentrations of pollutants in wastewaters for this sector will likely vary greatly from one facility to another. Each facility should assess its wastewater components, as the compounds listed in Table 2.1 may be found at higher, lower or negligible concentrations, depending on operating conditions and existing pollution prevention and treatment practices.

Table 2.1 Wastewater Concentrations in the Motor Vehicle Parts Manufacturing Sector

Substance	Representative Concentration in Wastewater (prior to pollution prevention or treatment) (mg/L)
Cadmium	10
Nonylphenol	0.15
Nonylphenol Ethoxylates	2.3

This BMP document addresses specifically the compounds listed in Table 2.1. Other compounds that may be present in the wastewater should be identified as they may be reduced by practices identified herein or by other practices.

2.1.1 Cadmium[6,7,8]

Cadmium and its compounds have been declared toxic substances under Section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), and added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

In the motor vehicle parts manufacturing sector, cadmium is used in metal shaping processes, metal coating, metal plating, and surface preparation. Cadmium is an elemental metal and can enter wastewater from the motor vehicle parts manufacturing industry through the processes of metal shaping and metal cutting when metal working fluids are used, metal plating operations in bath and rinse water and possibly cleaning and surface preparation. It is also used in solder and brazing.

Cadmium, a heavy metal, is found on vehicle surfaces. Cadmium is soluble and binds in oily waste. If exposed to an aqueous medium, the oily waste containing cadmium will emulsify in the water.

Table 2.2 illustrates where cadmium can be found in the motor vehicle parts manufacturing sub-sectors profiled in this document

Table 2.2 Cadmium in the Motor Vehicle Parts Manufacturing Sector

Sub-Sector	Where cadmium may be found in process
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing (NAICS 33631)	Wherever metal shaping, metal coating, metal plating, and surface preparation occurs.
Motor Vehicle Electrical and Electronic Equipment Manufacturing (NAICS 33632)	
Motor Vehicle Metal Stamping (NAICS 33637)	
Motor Vehicle Transmission and Power Train Parts Manufacturing (NAICS 33635)	
Motor Vehicle Motor Vehicle Brake System Manufacturing (NAICS 33634)	
Boiler, tank and shipping container manufacturing	
Steering and Suspension Components (except Spring) Manufacturing (NAICS 33633)	

[6] Pollution Prevention Assistance Division – Georgia Department of Natural Resources. (1996). *An Analysis of Pollution Prevention Opportunities and Impediments in the Fabricated Metal Products Manufacturing Sector in Georgia.* Retrieved May, 20, 2005 from http://www.p2ad.org/Assets/Documents/ma_fabmetal.htm

[7] National Centre for Manufacturing Sciences and National Association of Metal Finishers. (1994). *Blue Book: Pollution Prevention Control Technologies for Plating Operations.* Retrieved May, 20, 2005 from http://www.nmfrc.org/bluebook/tocmain.htm

[8] US EPA. (1995). Profile *of the Motor Vehicle Assembly Industry EPA Sector Notebook.* Retrieved May 20, 2005 from http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/motor.html

Metal Shaping Process

Shearing and forming operations are performed to cut materials into a desired shape and size, and bend or form materials into specified shapes. Wastewater is generated primarily during slag quenching operations (water is sprayed on the slag to both cool it and pelletize it) and by the wet scrubbers employed as air pollution control devices connected to furnaces and sand and shakeout operations. Due to the presence of cadmium and lead in iron, these metals may both be present in wastewater.

Metal working fluids are typically used to cool the part, aid lubrication, provide a good finish, wash away chips, and inhibit corrosion. This fluid waste may be considered hazardous due to contamination by metals like cadmium and lead. Typically, the scrap metal and metalworking fluids are disposed of or recycled. Metalworking fluids typically become contaminated and spent with extended use and re-use. When disposed, these oils may contain constituents of concern, including metals, such as cadmium, chromium, and lead.

Metal Plating Operations

Steel products are often coated to inhibit oxidation and extend the life of the product. Coated products can also be painted to further inhibit corrosion. Common coating processes include galvanizing, tin coating, chromium coating, and terne coating (lead and tin). Some water based coats are now being utilized. An example of a coated automotive part is the radiator, which is usually spray painted with a chromium coat to prevent corrosion. Rinse water from the coating process may contain zinc, lead, cadmium, or chromium.

Metal finishing and electroplating activities are performed on a number of metals and serve a variety of purposes, the primary purpose being protection against corrosion. This is particularly important to the automotive industry because of the harsh weather and road conditions to which automobiles may be subjected. Metal finishing and electroplating can also be performed for decorative purposes. These plating processes involve immersing the article to be coated/plated into a bath consisting of acids, bases, salts, etc.

The metals used in electroplating operations (both common and precious metal plating) include cadmium, lead, chromium, copper, nickel, zinc, gold, and silver. Cyanides are also used extensively in electroplating solutions and in some stripping and cleaning solutions.

The principal cause of waste in this sector is drag-out loss in transferring the work being surface treated from one process fluid to another or from process fluid to water-rinse prior to further processing. Other causes are mechanical loss from filtration systems and leakage or overfilling of process tanks. Spent or contaminated treatment solutions, together with spillage and leakage, are removed by a licensed waste disposal contractor either directly or after treatment in an on-site effluent treatment facility.

Metal Coating Operations

Pigments, used to formulate both primers and paints, are an integral part of the paint formulation, which also contains other substances. The pigmented resin forms a coating on the body surface as the solvent dries. The chemical composition of a pigment varies according to its colour. Red pigment contains cadmium.

Cleaning and Surface Preparation

Spray and immersion finishing methods are, to a certain extent, interchangeable, and the application method for various coatings varies from facility to facility. Similarly, the number and order of rinsing steps for cleaning, phosphating, and electrodeposition primer operations also varies. Spray rinsing the body prior to immersion rinsing decreases the amount of residues deposited in the bath and allows for greater solvent recovery. Depending on the stage of process, aqueous degreasing operations may also produce metal wastes.

2.1.2 Nonylphenol and its Ethoxylates (NPE)[9,10,11]

Nonylphenol and its ethoxylates have been declared toxic substances under Section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), and added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

In the motor vehicle parts manufacturing sector, NPE are used in solvents for surface preparation, metal processing, and in water based paints for metal coating. NPE are used in the preparation of the paint resin (polyvinylacetate), and also as a paint mixture stabilizer.[12] NPE are used in metal cleaning processes[13] (iron and steel manufacture); steel phosphating; electronics cleaning (for metal contacts); cleaning of metal products prior to storage; and formulation and usage of cutting and drilling oils.[14] NPE are also used in detergents for cleaning in the metal working industry. NPE are used in fluxes in the manufacture of printed circuit boards, in dyes to

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[9] Pollution Prevention Assistance Division – Georgia Department of Natural Resources. (1996). An Analysis of Pollution Prevention Opportunities and Impediments in the Fabricated Metal Products Manufacturing Sector in Georgia. Retrieved May, 20, 2005 from http://www.p2ad.org/Assets/Documents/ma_fabmetal.htm

[10] National Centre for Manufacturing Sciences and National Association of Metal Finishers. (1994). Blue *Book: Pollution Prevention Control Technologies for Plating Operations.* Retrieved May, 20, 2005 from http://www.nmfrc.org/bluebook/tocmain.htm

[11] US EPA. (1995). Profile *of the Motor Vehicle Assembly Industry EPA Sector Notebook.* Retrieved May 20, 2005 from http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/motor.html

[12] There are some uses of NPE which appear to confer an environmental benefit over the current alternatives in certain sectors, including certain water-borne auto refinishing (paint) products, which have been developed in response to the Montreal Protocol to replace solvent-based paints, which contain VOCs.

[13] Products for metal cleaning and preparation including immersion cleaners, spray cleaners, solvent degreasers, electrolytic cleaners and rinsing formulations.

[14] Department of the Environment, Transport and Regions. (2000). Nonylphenol *Risk Reduction Strategy*. Retrieved June 7, 2005 from http://www.rpaltd.co.uk/tools/downloads/reports/nonylphenol.pdf

identify cracks in printed circuit boards, and as a component of chemical baths used in the etching of circuit boards.

NPE are part of the alkylphenol ethoxylate (APE) group of non-ionic surfactants. The wetting properties of NPE surfactants are of particular importance for degreasing (i.e., cleaning); where the surface tension of the cleaning solution has to be low enough to wet the entire surface of the material to be degreased. Likewise, NPE are important where chemical or cleaning formulations need to be dispersed to every part of the component or product.

Once NPE are released to sewage treatment systems, several transformations can occur. The mechanism of degradation is complex, but, in general, there is an initial loss of ethoxylate (EO) groups from the original moiety (i.e., molecule). Under aerobic and anaerobic treatment conditions, biodegradation to more toxic (and estrogenic) metabolites occurs. NPE can be biodegraded through a mechanism of stepwise loss of ethoxy groups to form lower ethoxylated congeners, carboxylated products, and nonylphenol. The intermediate and final products of metabolism are more persistent than the parent NPE, but these intermediates are expected to be ultimately biodegraded. The concentration of nonylphenol is generally low in treated effluents, as it degrades and sorbs to sludge particles.[15]

Table 2.3 illustrates where NPE can be found in the motor vehicle part manufacturing sector.

[15] Environment Canada. (2002). Assessment Report-Nonylphenol and its Ethoxylates. Accessed June 21, 2005 from http://www.ec.gc.ca/substances/ese/eng/psap/final/npe.cfm

Table 2.3 NPE in the Motor Vehicle Parts Manufacturing Sector

Sub-Sector	Where NPE may be found in process
Motor Vehicle Gasoline Engine and Engine Parts Manufacturing (NAICS 33631)	Instances of surface preparation, cleaning, and degreasing
Motor Vehicle Electrical and Electronic Equipment Manufacturing (NAICS 33632)	
Motor Vehicle Metal Stamping (NAICS 33637)	
Motor Vehicle Transmission and Power Train Parts Manufacturing (NAICS 33635)	
Motor Vehicle Motor Vehicle Brake System Manufacturing (NAICS 33634)	
Boiler, tank and shipping container manufacturing	
Steering and Suspension Components (except Spring) Manufacturing (NAICS 33633)	

Cleaning and Surface Preparation

Numerous methods are used to finish metal products. However, prior to applying the finishing application, the surface must be prepared. One of the most important aspects of a finished product is the surface cleanliness and quality. Without a properly cleaned surface, even the most expensive coatings will fail to adhere or prevent corrosion.

NPE are used in metal cleaning[16] during iron and steel manufacture, steel phosphating, electronics cleaning, and metal cleaning prior to storage.[17] With respect to the types of products containing NPE, these are mainly alkaline and acid cleaners. Alkaline cleaning occurs as a part of both metal processing and electroplating to prepare metal surfaces for further applications. Alkaline cleansers are used to remove mineral oils and animal fats and oils from the steel surface. Alkaline cleaners can be either solvent-based or water-based. The cleaner chosen depends on the nature of the finishing process and associated requirements. Acid cleaners have a very limited use in metal processing with one of the main applications being in the production of printed circuit boards. Acid cleaners are used to activate metal prior to plating with other metals (i.e., they are used after cleaning but prior to electroplating). The choice of surfactant is critical, as it is important that none is left

[16] Products for metal cleaning and preparation including immersion cleaners, spray cleaners, solvent degreasers, electrolytic cleaners and rinsing formulations

[17] Department of the Environment, Transport and Regions. (2000). Nonylphenol *Risk Reduction Strategy*. Retrieved June 7, 2005 from http://www.rpaltd.co.uk/tools/downloads/reports/nonylphenol.pdf

behind on the surface after water rinsing. NPE are also used in the acid de-scalers used in metal treatment, for example, in the acid baths used for cleaning engine blocks.

APE may be present in products used to remove protective coatings from new cars and in heavy-duty hand cleaning agents.[18] In addition to use in metal processing, electroplating, and tank cleaning, APE may also be present in the degreasing agents used on motor and machinery parts. Degreasers may be either water-based or solvent-based. APE may be used as emulsifiers in the former and as wetting agents in the latter. In both cases, APE will be present in concentrations in the range 5% to 10%.

Metal Processing

NPE are used in metal processing in industrial lubricants, such as metalworking fluids. They form part of the ready-made additives packages supplied to the formulators of industrial lubricants and are reported to be widely applied throughout the whole of the industry. The main use of NPE are as supplementary emulsifiers in water-extendable (water-miscible) metalworking fluids where they are used to achieve stable emulsions. For example, one company has been identified which uses NPE in grinding fluids. There is also limited application of non-ionic emulsifiers, such as NPE in some neat oils, where they are required to be water-washable, for example, in quenching oils. NPE are also present in system cleaning fluids (i.e., those used to clean the metalworking fluid system when replacing fluids).

Metal Etching Processes

Etching is the process used to produce specific design configurations or surface appearances on parts by controlled dissolution with chemical reagents or etchants. Etching solutions are commonly made up of strong acids or bases with spent etchants containing high concentrations of spent metal. The solutions include ferric chloride, nitric acid, ammonium persulfate, chromic acid, cupric chloride, and hydrochloric acid.

Electrical Components

Review of the literature has identified four uses of NPE in the manufacture and cleaning of printed circuit boards. NPE are used in chemical baths as part of the etching of printed circuit boards. Acid cleaners are one of two types of chemical cleaners used in metal processing. Such products have very limited use with one of the main applications being in the production of printed circuit boards. The cleaners are used here to activate copper prior to plating with other metals, such as gold. The choice of surfactant is critical, as it is important that none is left behind on the surface after water rinsing. Consultation with a manufacturer of electroplating solutions has indicated that NPE are used mainly in additives to the electroplating

[18] NPE are found in automotive products such as traffic film remover, wash & wax, car shampoos, windscreen washes, pressure cleaners, chrome cleaners, rinse formulations, engine degreasers and upholstery cleaners.

solutions used to produce printed circuit boards. NPE are also used on one or two electronic components. NPE are also present in some non-destructive testing (NDT) chemicals used by some of the electronics industry to identify defects in printed circuit boards. One major producer of fluxes has indicated that some of their older fluxes do contain nonylphenol derivatives. Data also indicates that NPE are in at least one of the hand soldering fluxes produced by a German company.

More generally, NPE may be used in the cleaning of electronic components and specifically printed circuit boards. If so, NPE would be used as surfactants in water washes, which have been developed as one of the replacements for the solvent-based [e.g., chlorofluorocarbons (CFC) –based] cleaning systems phased out as a result of the Montreal Protocol.

2.2 Reference Criteria for Concentrations of Substances of Interest in Discharges to Sewers

This sub-section identifies the reference criteria for substances of concern. In developing the BMP guidance documents, three reference criteria were considered with respect to final effluent concentrations for harmful substances. In Table 2.4, Reference Criteria 1 are the most stringent; that is, Reference Criteria 1 are the lowest reference criteria, whereas Reference Criteria 3 are the least stringent reference criteria. Due to the methodology applied to develop the reference criteria, as elaborated below, two of the three reference criteria are the same in several instances.

Table 2.4 Reference Criteria for Substances in the Motor Vehicle Parts Manufacturing Sector

Substance	Designation	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Cadmium [1]	COA* Tier II	0.0006	0.02	1
Nonylphenol	CEPA** Toxic	0.001	0.001	0.0025
Nonylphenol Ethoxylates	CEPA Toxic	0.001	0.01	0.025

Notes:

*COA: Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem
**CEPA: Canadian Environmental Protection Act

1. 0.0006 mg/L was used for Criteria 1 for cadmium due to current analytical laboratory detection limit capabilities.

The *Canadian Environmental Protection Act, 1999* (CEPA) is the cornerstone of the Government of Canada's environmental legislation aimed at preventing pollution and protecting the environment and human health. CEPA recognizes the contribution of pollution prevention and the management and control of toxic substances and hazardous waste to reducing threats to Canada's ecosystems and biological diversity. CEPA acknowledges the need to virtually eliminate the most persistent toxic substances that remain in the environment for extended periods of time before

breaking down, and bioaccumulative toxic substances that accumulate within living organisms.

From a regulatory perspective, pollution prevention planning becomes one of the tools Environment Canada risk managers can use to address Schedule 1 CEPA toxic substances. Facilities that use Schedule 1 CEPA toxic substances should be aware of the impact that CEPA may have on them.

Reference Criteria 1

Substances identified in the Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem (COA) are either Tier I substances, subject to virtual elimination, or Tier II substances, targeted for reduction. Column 2 of Table 2.4 identifies substances subject to the COA. For substances identified in the COA, Reference Criteria 1 are the more stringent of the Recommended Method Detection Limit (RMDL) or the Provincial Water Quality Objective (PWQO).

For other substances not subject to COA, Reference Criteria 1 are the more stringent of 20 times the PWQO or 20 times the RMDL except for NPE, where Reference Criteria 1 are the threshold identified in the Canadian Environmental Quality Guidelines, Canadian Council of Ministers (CCME) of the Environment, 2002.

Reference Criteria 2

Reference Criteria 2 were established by the minimum values identified in municipal sewer use by-laws in Ontario for the identified substances. In cases where the sewer use by-law limit was the same as the PWQO or RMDL, Reference Criteria 2 are the same as Reference Criteria 1.

Reference Criteria 3

Reference Criteria 3 were established by the median values identified in municipal sewer use by-laws in Ontario for the identified substances. In cases where only one by-law identified a limit for the substance, or where the same limit was identified in all by-laws, Reference Criteria 3 are the same as Reference Criteria 2.

2.3 Select Regulatory Requirements for the Substances Addressed

Toxic and hazardous substances may be subject to several regulations at the federal, provincial, and municipal levels, in addition to international agreements and protocols. It is incumbent on owners and operators of industrial facilities to be knowledgeable of all management and reporting requirements for specific substances used in, produced by, transported to and from, or otherwise used at, or released from, their facilities and operations.

The following section is intended as a guide only regarding specific regulations. Proponents are advised to consult these regulations directly to ensure they have all information they require. Requirements discussed in this section include municipal

sewer use by-laws, the National Pollutant Release Inventory (NPRI) and the federal Environmental Emergency requirements.

Municipal Sewer Use By-laws

The majority of municipalities in the province of Ontario have municipal sewer use by-laws. A wide range of materials, chemicals, and conditions for discharge are identified in the sewer use by-laws with corresponding objectives that may include the following:[19]

- Protection of the environment;
- Protection of municipal staff and infrastructure;
- Efficient use of the system;
- Prevention of stormwater and 'clear' water from entering the system;
- Protection of sludge or biosolids quality; and
- Protection of public health and safety and protection of public property.

Some municipal sewer use by-laws include an option for entering into over-strength agreements with industrial dischargers, although these agreements are typically limited to substances intended for treatment by the community wastewater treatment facility and do not include the toxic substances addressed in this document. Some municipal sewer use by-laws also require pollution prevention planning and reporting by industrial facilities. Proponents are encouraged to access the municipal sewer use by-law pertaining to the community sewer system into which they discharge to ensure they are in compliance with all discharge and reporting requirements of the by-law.

Canada's National Pollutant Release Inventory

The NPRI has several reporting thresholds, including number of employee hours, quantities, and concentrations of reportable substances manufactured, processed, or otherwise used, with requirements pertaining to specific cases where substances are produced as by-products. Practitioners are encouraged to reference the NPRI website[20] directly for the most recent reporting requirements, including reportable substances and reporting thresholds, as these may change over time. There are over 330 substances and substance groups reportable under NPRI; Table 2.5 identifies the substances of interest for this BMP document.

[19] Review of Existing Municipal Wastewater Effluent (MWWE) Regulatory Structures in Canada, Marbek Resource Consultants for the Canadian Council of Ministers of the Environment (CCME), 2005

[20] NPRI website: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

Table 2.5 NPRI Reporting Requirements (2003) for Substances in the Metal Vehicle Products Sector

Substance	NPRI Reportable Substances	NPRI Part Designation	Reporting Threshold
Cadmium	Cadmium and its compounds	Part 1B	5 kg
NPE	Specific substances	Group 1A	10 tonnes (total in 2003)

The likelihood of the sector meeting the NPRI reporting requirements is fairly high because of the scale of most operations of this nature. The only limiting factor would be whether the quantity of reportable substances was high enough.

Federal Environmental Emergency (EE) Regulation

Environmental Emergency (EE) Regulations under Part 8 of the Canadian Environmental Protection Act (CEPA), 1999, promote prevention and planning for preparedness, response, and recovery. Neither of the two substances discussed in this document are identified in the federal emergency regulation at this time. Practitioners are encouraged to reference the regulatory requirements at Environment Canada's website.[21]

MOE Spills Action Centre

When a spill occurs, it is the responsibility of the owner and the person who had control of the pollutant at the time it was spilled to clean up and dispose of the pollutants and ameliorate any adverse effects in a timely manner. It is the Ministry's role to ensure that those responsible take preventative measures and use proper clean up, disposal, and amelioration practices. Under the Environmental Protection Act, the Ministry can order those responsible for the spill to clean up the site.

The MOE should be contacted (Spill Action Centre 1-800-268-6060) if the spill is discharged to a storm water system and into the natural environment, migrates off-site or where the spill occurs off-site. In such a situation, the MOE, the municipality and the controller, and/or owner of the pollutant, if different, are to be notified.

[21] Environment Canada EE Regulatory Requirements website: http://www.ec.gc.ca/ee-ue/default.asp?lang=En&n=8A6C8F31-1

3. POLLUTION PREVENTION

Pollution prevention (P2) is defined as "the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste, and reduce the overall risk to the environment or human health."[22] P2 practices therefore include elimination of hazardous substances through materials substitutions (Section 3.2); reduction of hazardous substances through process or equipment modifications (Section 3.2); operating procedures and housekeeping practices (Section 3.3); and education and training of staff, suppliers, customers, and the public (Section 3.4). P2 measures can be undertaken concurrently. The most effective actions are those that eliminate hazardous substances, through substitution, for example.

Treatment (Section 4) is not a pollution prevention activity. For many substances, treatment moves pollutants from one media to another (e.g., removal of a metal from the water effluent to a solids residue) and does not avoid or minimize the creation of the pollutant or waste.

Pollution prevention and treatment BMPs must be assessed and implemented based on specific site and process conditions and characteristics; however, some overall observations can be made about effective ways to proceed with assessment and implementation of BMPs. Specific options for the motor vehicle parts manufacturing sector for P2 are outlined in the sub-sections following.

The best way to improve environmental management issues is to use a systematic approach. One key first step is to develop an environmental policy and strategy that is formally supported through senior management's commitment to the strategy. An Environmental Management System (EMS) is a tool that organizations in a variety of sectors have implemented to systematically identify, prioritize, and take action to address the environmental impacts of their operations and services. In addition, an EMS can establish the record-keeping and reporting required to ensure facility management has the necessary information for continuous improvements. It is recommended that all facilities consider developing, adopting, and implementing an EMS. One example of such a system is the ISO 14001 standard. Pollution prevention, product stewardship, and social responsibility are important aspects of a comprehensive, integrated environmental approach. Employee engagement and training, communication throughout the supply chain, and customer education may be appropriate elements for a successful, integrated approach to long-term sustainability.

General best available techniques (BAT) for the EMS at motor vehicle parts fabrication and manufacturing facilities include the following:

- An environmental strategy and a commitment to follow the strategy.

[22] Definition in: Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the *Canadian Environmental Protection Act*, 1999 (CEPA 1999), National Office of Pollution Prevention, Environment Canada, 2001

- Organizational structures to integrate environmental issues into decision-making, including, for example, implementing a requirement that chemicals new to the facility not be purchased without undergoing an environmental review.

- Written procedures or practices for all environmentally important aspects of plant design, operation, maintenance, commissioning, and decommissioning.

- Internal audit systems to review the implementation of environmental policies and to verify compliance with procedures, standards, and legal requirements.

- Accounting practices that internalize the full costs of raw materials and wastes.

- Long-term financial and technical planning for environmental investments.

- Control systems for the core process and pollution control equipment to ensure stable operation, high yield, and good environmental performance under all operational modes.

- Systems to ensure operator environmental awareness and training.

- Inspection and maintenance strategies to optimize process performance, including implementing monitoring and reporting programs.

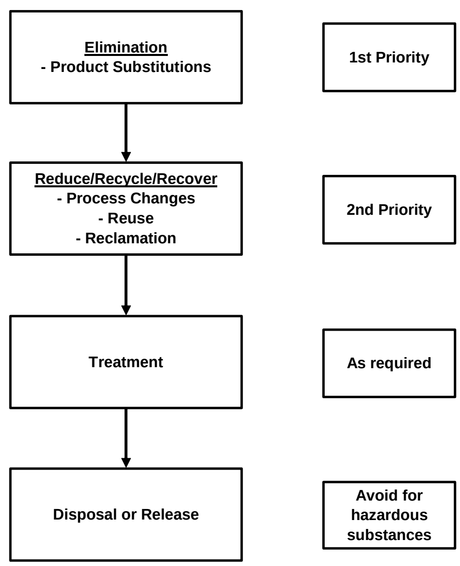
- Implementation of an inspection and recording program for all input and output materials, including defined chemicals labelling, storage, handling, and disposal practices.

- Defined response procedures to abnormal events.

- On-going waste minimization exercises.

The following sequence of steps (Figure 3) presents a hierarchy of techniques for undertaking pollution prevention and waste minimization:

Figure 3.1 Environmental Management Options Hierarchy



- Eliminate generation of waste streams through process development and design;
- Reduce waste streams at source through process-integrated changes to raw materials, equipment, and operating procedures;
- Recycle waste streams by direct re-use or reclamation and re-use;
- Recover any resource value from waste streams; and
- Treat and dispose of waste streams using end-of-pipe techniques.

The sequence of general techniques to prevent and minimize release of water pollutants includes the following steps:

- Identify all wastewater streams and characterize their quality, quantity, and variability;
- Minimize quantity of water used in the process;
- Minimize contamination of process water and washwater contamination with hazardous raw materials, product, or wastes;
- Maximize wastewater re-use; and
- Maximize the recovery and retention of substances from streams unfit for re-use.

The motor vehicle parts manufacturing sector includes a large variety of processes and chemical reactions, depending on the type of motor vehicle part or product being fabricated or manufactured. Consumption and emission levels are very specific to each process and are difficult to define and quantify without detailed study. P2 opportunities and BMPs are therefore site and process specific.

3.1 Overview of P2 Measures for Cadmium and NPE in the Motor Vehicle Parts Manufacturing Sector

This sub-section provides an overview of the P2 measures discussed in the following three sub-sections: 3.2 Pollution Elimination or Reduction; 3.3 Operating Procedures and Housekeeping; and, 3.4 Education and Training.

Table 3.1 Overview of P2 Measures for Cadmium and NPE in the Motor Vehicle Parts Manufacturing Sector

P2 Type	Substance Addressed	BMP Name	BMP Number
Elimination/Reduction	Both NPE & Cadmium	Maximize the use of recycled water	BMP #1
	Both NPE & Cadmium	Process fluid waste minimization	BMP #2
	Both NPE & Cadmium	Reduce waste from spray-painting	BMP #3
	Both NPE & Cadmium	Reduce drag-out loss in metal plating operations	BMP #4
	Both NPE & Cadmium	Drag-out return recovery technologies for metal plating operations	BMP #5
	Both NPE & Cadmium	Rinsewater reductions for metal plating operations	BMP #6
	Cadmium	Solder substitution	BMP #7
	Cadmium	Material substitution for cadmium plating	BMP #8
	Cadmium	Air cooling as a replacement for cooling oils	BMP #9
	Cadmium	Alternative deposition methods	BMP #10
	NPE	Material substitution for NPE containing products	BMP #11
	NPE	Material substitution for NPE containing cleaning and surface preparation products	BMP #12

Table 3.1 (cont'd) Overview of P2 Measures for Cadmium and NPE in the Motor Vehicle Parts Manufacturing Sector

P2 Type	Substance Addressed	BMP Name	BMP Number
Operating Procedures and Housekeeping	Both NPE & Cadmium	Contain all above-ground tanks containing liquids, whose spillage could be harmful to the environment	BMP #13
	Both NPE & Cadmium	Effective operational and maintenance systems	BMP #14
	NPE	Maintain optimum concentration range for NPE containing metal processing products	BMP #15
	NPE	Maintain optimum concentration range for etching baths containing NPE	BMP #16
	Both NPE & Cadmium	Accident prevention	BMP #17
Education and Training	Both NPE & Cadmium	Management and staff training	BMP #18

3.2 Pollution Elimination or Reduction

P2 opportunities to eliminate or reduce hazardous substances include material substitutions and process alterations. Changes in operating costs will depend on the cost differential of the substitute in comparison with the hazardous material. Where the cost of the substitute is higher, operating costs will increase; however, where the cost of the substitute is lower, operating costs will decrease. Some capital investment in equipment modifications or replacements to accommodate any differences in properties of the substitute substances may also be required. Alterations to processes to reduce use of hazardous substances may entail changes in operating budget, including possible reductions in costs due to more efficient operations. Capital investment for equipment modification or replacement may also be required.

3.2.1 Reduction Measures Common to All Substances of Interest

The following BMPs outline measures to reduce the release of cadmium and NPE in the Motor Vehicles Parts Manufacturing process.

BMP #1: Maximize the use of recycled water: Water should be recycled within the process from which it issues, by treating it first if necessary. Filtration/osmosis or other techniques can be used which allow the effluent water to be cleaned for return to the process. This reduces the need for new solution to be added to the original process.

BMP #2: Process fluid waste minimization: There are various methods to improve the efficiency of process fluid, such as using lower concentration process fluids,

using process fluids of lower viscosity, using drag-out minimization techniques, and using multistage cascade rinsing. These methods extend the life of the process fluids.

BMP #3: Reduce waste from spray-painting: Establishing a standardized procedure for cleaning paint spraying equipment and paint booths during colour changes, in combination with a schedule to reduce the number of cleanings required, is effective in reducing waste volumes.

Metal Plating Operations

BMP #4: Reduce Drag-out loss: Many devices and procedures are used successfully to reduce drag-out. These techniques usually are employed to alter viscosity, chemical concentration, surface tension, velocity of withdrawal, and temperature. Also used are drag-out tanks and similar equipment for capturing lost plating solution and for returning it to the bath. Techniques that may be employed to reduce drag-out losses include the following:

- Control the plating solutions, workpiece position on rack, workpiece withdrawal, and the design and maintenance of racks and barrels. Design racks for maximum drainage by encouraging clients to provide drainage holes in hollow or tubular work.
- Minimize drag-out by maximizing the drainage time of the work over the plating tank or in a separate drainage tank. Drainage times should not be less than 20 seconds for rack plant and 30 seconds for barrel plant.
- Allow longer drip/draining times in the transfer of work from one tank to the next.
- Mechanical recovery and return of drag-out solution upstream.
- Recovery of anode metals from drag-out that cannot be returned upstream.

Drag-out recovery will reduce drag-out losses by 50% or more. Two-stage drag-out will reduce drag-out losses by 70% or more and multiple drag-out tanks will reduce drag-out losses by up to 100%.[23] Ensure that the drain time for pieces is at least 10 seconds for a dual or multiple drag-out system to reduce drag-out by 40+%, which is generally longer when compared to the industry average of three seconds. Note however, that the ideal drain time for rack and barrel plants, including transfer between tanks, is longer than a multiple drag-out system.

BMP #5: Drag-out return recovery technologies: Technologies can reduce chemical consumption, as well as the amount of rinsewater. The technologies range from simple, cost effective systems, such as the use of drain boards, to use of electrochemical metals recovery technology for unreturned drag-out. More elaborate technologies include ion exchange; reverse osmosis; electrodialysis; evaporation; draining, such as drip shield (tilted surface), air knife (intensive air stream), drip tank

[23] National Centre for Manufacturing Sciences and National Association of Metal Finishers. (1994).

(empty tank), and drag-out tank (filled with pure water); and rinsing over the plating tank (such as flood rinsing, spray rinsing, or fog rinsing).

Use of air-swept evaporation technology in conjunction with 3-5 stage cascade rinsing to allow closed loop operation for hot (35°C plus) plating processes, i.e., 100% return of drag-out.[24]

BMP #6: Rinsewater Reductions: The proper design of rinsing systems is essential for water conservation and for the prolongation of process fluid life. Adequate rinsing is necessary to ensure that the finished work is chemically clean, especially when the final treatment (plating or passivation) uses, or is based on, hexavalent chromium. Rinsing quality is defined as the ratio of the concentration of a metal or other ion in the preceding process tank to its concentration in the final rinse tank. Effective rinsing ratios depend on the process concentration, and the quality of rinsing required. Single rinse tanks, whether used for interstage rinsing or as a final rinse, are ineffective unless a very large volume of water is used, or the rinse water is recirculated by use of an ion exchange (or other treatment) unit. Cascade (counterflow) rinsing in two or more stages reduces the water requirement to a low level, while improving the quality of rinsing.

In order to maximize opportunities for rinsewater reduction, the facility should have optimal rinse tank design. Various other techniques, such as flow restrictions, manual control of water flow, conductivity controls, solenoid valve on automated plating machines, timer rinse controls, flow meters, and accumulators, help control the flow rate of rinsewater use. Alternative rinse configurations such as counterflow rinsing, cascade reactive and dual purpose rinsing, chemical rinsing, spray rinsing, or combined drag-out/rinsewater reduction rinsing arrangements also help to maximize opportunities for rinsewater reduction. Multi-stage cascade rinsing is a must for facilities looking to achieve significant wastewater reduction. A minimum of two stages or multistage cascade rinsing, with agitation, are considered optimal for achieving adequate to significant rinsewater reduction.

3.2.2 Reduction Measures for Cadmium

Measures to avoid or eliminate the use of hazardous substances are the most desirable P2 measures since these are the most effective means to ensure environmental protection. Substitutions of process materials that contain cadmium with materials that do not contain cadmium should be considered whenever possible.

The cadmium emissions to sewer based on the use of best available technique (BAT) is zero; however, an acceptable level of detection has been established as 0.01 mg/L.[25] The typical process efficiency with BAT implementation for cadmium is 99%.[26] Filtration to remove fine suspended solids to achieve trade effluent consent

[24] Environment Agency. (2004). Guidance *for the Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes.* Bristol. Environment Agency.
[25] Environment Agency. (2004). *Guidance for the Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes.* Bristol. Environment Agency.
[26] Ibid.

limits for metals of 1-3 mg/L is common. Effluent, whether filtered or not, may be recycled to the less critical rinsing steps and thus reduce input water usage by up to 30%.[27]

BMP #7: Solder Substitution: Certain silver brazing fillers give off cadmium and zinc fumes; many users are changing to cadmium-free filler metals. There are suitable alternatives for many existing applications using cadmium-bearing solders.

BMP #8: Material substitution for cadmium plating: Full consideration of substitutions for cadmium plating should be made, e.g., zinc-nickel and tin–zinc alloy processes, where available. Proprietary plating systems can be used, such as 1) proprietary plating electrolytes that have a low concentration of dissolved solids and operate with minimum energy requirements for heating or cooling; and/or 2) proprietary systems which provide a long process fluid life, which do not contain cadmium and which require relatively simple effluent treatment.

BMP #9: Air cooling as a replacement for cooling oils: Use of synthetic fluids can often significantly increase fluid life. For some applications, air can be used as a coolant replacing the oils. Laser cutting, water jet cutting, plasma arc welding, and computer numerical control (CNC) machining are all potential technologies that can be considered for reducing wastes in high volume shops or those with high dollar value.[28]

BMP #10: Alternative deposition methods: Methods for depositing metal coatings, such as chromium, nickel, cadmium, and copper in traditional electroplating processes have inherent pollution problems. Several alternative technologies exist to coat a substrate with metal without using electrolytic solutions or plating baths. These technologies do not eliminate the use of metal coatings, but they do eliminate the use of non-metal toxic components, such as cyanide from the plating process. They also can reduce the amount of metal-contaminated wastewater and sludge that is generated from plating. These alternative technologies include thermal spray coating, vapour deposition, and chemical vapour deposition.[29]

Additionally, cadmium plating carried out in an alkaline cyanide-based electrolyte has effectively prevented the release of cadmium to sewer.[30]

3.2.3 Reduction Measures for NPE

Due to the concern for NPE, governments are taking action to reduce the use of NPE in the marketplace. In Canada, owners or operators of facilities that manufacture soap and cleaning products, processing aids used in textile wet processing, or pulp and paper processing aids, as well as importers and bulk purchasers of NPE, are required to prepare and implement a pollution prevention plan. The P2 plan must

[27] Ibid.
[28] Pollution Prevention Assistance Division – Georgia Department of Natural Resources. (1996).
[29] Illinois Waste Management and research Centre. (nd).
[30] Environment Agency. (2004). Guidance *for the Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes.* Bristol. Environment Agency.

reduce by 50% the mass of NPE used or imported annually by the year 2007 and reduce the mass used or imported annually by 95% by the year 2010. (See Environment Canada's Canada Gazette Notice for precise requirements.[31])

Canada's steps are similar to those of the European Union (EU), which as of January 2005, under the 26th amendment to Directive 76/796/EC, requires that NPE may not be placed on the market or used as a substance or constituent of preparations in concentrations equal to or higher than 0.1% weight to weight in a number of applications. The exceptions to this list of applications are processes with no release into wastewater, including those with special treatment where washing liquid is recycled or incinerated.

BMP #11: Material substitution for NPE containing products: NPE can be removed either by reformulating fluids to avoid the need for supplementary emulsifiers or where this is not possible, by replacing NPE with other non-ionic surfactants. Formulators have indicated that there are a wide range of alcohol ethoxylates, which could be used as substitutes to NPE, with the choice varying according to the specific formula and/or application. As metalworking fluids comprise 1-2% of estimated nonylphenol releases to the environment, eliminating this use would make a small but significant contribution to reducing environmental loads.

BMP #12: Material substitution for NPE containing cleaning and surface preparation products: In general, for cleaning and surface preparation, the concentration of NPE in alkaline cleaners is estimated to be <5%, about 1% to 2%. Cleaners are generally purchased in concentrate form and diluted at the point of use. Electrolytic cleaners are specialist types of cleaner in which the electrical properties of the solution are important. The cleaner performs when a current is passed across a cell. This produces hydrogen and oxygen, which scours the metal. At the same time, chemicals in the cleaner dissolve the surface of the metal to be cleaned. Cleaner producers indicate that their products contain <5% NPE and are used at a concentration of 50 - 75 g/litre.[32] Concentrations of NPE in acid cleaners are reported to be <15% in general.[33]

3.3 Operating Procedures and Housekeeping

Operating procedures and housekeeping BMPs are P2 measures that can be implemented concurrently with elimination/reduction BMPs and education/training BMPs. Some operating costs may be incurred to initiate improved operating and housekeeping practices, for example, to establish an inventory control system. Once implemented, however, these costs can be expected to be off-set by optimized performance, reduced losses of time and materials, reduced liability, better-informed

[31] Website: http://www.ec.gc.ca/Ceparegistry/documents/notices/g1-13849_n4.pdf

[32] Department of the Environment, Transport and Regions. (2000). *Nonylphenol Risk Reduction Strategy*. Retrieved June 7, 2005 from http://www.rpaltd.co.uk/tools/downloads/reports/nonylphenol.pdf

[33] Ibid.

staff and management, and, potentially, improved customer satisfaction. Reliable record-keeping systems are needed to realize the full benefits of operating procedures and housekeeping BMPs. Minimal capital investment to implement operating and housekeeping BMPs can be expected.

BMP #13: Contain all above-ground tanks containing liquids whose spillage could be harmful to the environment: Containers should:

- Be impermeable and resistant to stored materials;
- Have no outlet and drain to a blind collection point;
- Have pipework routed within contained areas with no penetration of contained surfaces;
- Be designed to catch leaks from tanks or fittings;
- Have a capacity greater than 110% of the largest tank or 25% of the total tankage, whichever is larger;
- Be subject to regular visual inspection;
- Where not inspected, be fitted with probe and alarm; and
- Be subject to engineering inspection.

BMP #14: Effective operational and maintenance systems: Effective operational and maintenance systems should be employed on all aspects of the process whose failure could impact on the environment. In particular there should be:

- Documented procedures to control operations that may have an adverse impact on the environment;
- A defined procedure for identifying, reviewing, and prioritizing items used in the plant for which a preventative maintenance regime is appropriate;
- Documented procedures for monitoring emissions or impacts;
- A preventative maintenance program covering all plant operations, whose failure could lead to impact on the environment, including regular inspection of major ‘non productive’ items, such as tanks, pipework, retaining walls, containing ducts, and filters; and
- The maintenance system should include auditing of performance against requirements arising from the above and reporting the result of audits to top management.

BMP #15: Maintain optimum concentration range for NPE containing metal processing products: In metalworking fluid concentrates, where NPE act as supplementary emulsifiers, they will be a minor component at a concentration in the

order of 1% to 5%. One company using NPE has indicated[34] that nearly half its formulations contain <1% NPE, while another indicates[35] that the maximum concentration in its products is 2% to 3%. Concentrates are then diluted in the ratio of around 20:1 (water to concentrate), although dilution can be as high as 50:1.

BMP #16: Maintain optimum concentration range for etching baths containing NPE: Concentrations of NPE in these etching baths for electrical components are reported to be in the range 5% to 10%.

BMP #17: Accident Prevention: Plans for accidents/incidents/non-conformance should include:

- Identification of the likelihood and consequence of accidents;
- Identification of actions to prevent accidents and mitigate any consequences;
- Written procedures for handling, investigating, communicating, and reporting actual or potential non-compliance with operating procedures or emission limits;
- Written procedures for handling, investigating, communicating, and reporting environmental complaints and implementation of appropriate actions;
- Written procedures for investigating incidents (and near misses), including identifying suitable corrective action and following up;
- Establishment of an inventory control system; and
- Requirement to perform routine and preventative maintenance on facility equipment that come in contact with NPE.

3.4 Education and Training

Education and training are P2 measures that can be implemented concurrently with elimination/reduction BMPs and operating/housekeeping BMPs. Investments in education and training for management and staff can return significant benefits, including improved staff motivation, an improved health and safety record, reduced material losses, improved productivity, and, potentially, improved customer satisfaction. Communication and education of the supply chain, including material and equipment suppliers, can result in improved working relationships, as well as environmental benefits resulting from reduced pollution release.

It is important to keep education and training current and to ensure a management system is in place to maintain the relevance of education and training delivered. As

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[34] Department of the Environment, Transport and Regions. (2000). *Nonylphenol Risk Reduction Strategy*. Retrieved June 7, 2005 from http://www.rpaltd.co.uk/tools/downloads/reports/nonylphenol.pdf

[35] Ibid.

mentioned above, a comprehensive management approach is important for effective reduction of releases of hazardous substances, including reductions through education and training.

Some operating costs may be incurred to initiate education and training practices, for example, time required to discuss improved materials specifications with suppliers. Once implemented, however, these costs can be expected to be off-set by the benefits of education and training. Capital investment is not typically required for implementation of education and training practices.

BMP #18: Management and Staff Training:

Employee Education including:

- Training systems, covering the following items, should be in place for all relevant staff:
  - Awareness of the regulatory implications of their work activities;
  - Awareness of all potential environmental effects from operation under normal and abnormal circumstances;
  - Awareness of the need to report deviation from the regulation;
  - Prevention of accidental emissions and action to be taken when accidental emissions occur.
- The skills and competencies necessary for key posts should be documented and records of training needs and training received for these post maintained.
- The key posts may include contractors and those purchasing equipment and materials.
- The potential environmental risks posed by the work of contractors should be assessed and instructions provided to contractors about protecting the environment while working on site.
- Where industry standards or codes of practice for training exist they should be complied with.

3.5 P2 Options and Costs

The rationale for selection of BMPs and associated cost estimates is outlined in this section. In general, information on the effectiveness and cost of P2 measures is not well documented in literature. Therefore, a number of estimating procedures were made with respect to the effectiveness and costs of implementing BMPs to eliminate or reduce the substances of concern. In the absence of specific information, rules of thumb were developed for each type of P2 measure, as summarized below.

Data in literature with respect to substance removal effectiveness of P2 measures is very sparse. Where data is provided, there is wide variability in results. Further, costs and cost savings information are not provided with sufficient context to be useful for this analysis. In the absence of directly relevant data, several rules of thumb were developed for P2 effectiveness and cost estimations were based on available literature information. Case study information from a range of literature sources for the six sectors of interest was researched to identify P2 effectiveness experience for any substance. These case study results were grouped by type of P2 measure and the data was assessed to derive a reasonable range of substance removal effectiveness. The following Table provides a summary of the rules of thumb for P2 effectiveness.

Table 3.2 Rules of Thumb for P2 Effectiveness

Type of P2 Measure	Percent Reductions in Releases			
	Material Substitution	**Process Modification**	**Operating/ Housekeeping**	**Education and Training**
Sub-Section title in BMP Document	Pollution Elimination or Reduction	Pollution Elimination or Reduction	Operating Procedures and Housekeeping	Education and Training
Rule of Thumb to Apply (in absence of specific information)	50% to 75%	10% to 40%	10% to 30%	1% to 30%

In the absence of directly relevant data for P2 costs, it was assumed that P2 costs primarily impact operating budgets, except in the case of process modifications where capital investments were also assumed to be required. Extrapolations of operating costs were derived from Statistics Canada data on annual average earnings by company size for manufacturing and service sector groups.

Table 3.3 Rules of Thumb for P2 Costs

P2 Rules of Thumb	Range of Costs			
Type of P2 Measure	**Material Substitution**	**Process Modification**	**Operating/ Housekeeping**	**Education and Training**
Rule of Thumb to Apply (in absence of specific information)	Materials budget implications of -2% to 4%; may be negligible for some materials that are easily substituted but costly in other applications	¼ person year to 5 person year per modification, plus capital investment (annualized $5,000 per year for manufacturing sectors; $1,000 per year for service)	½% to 5% increase in operating budget staff time (off-set over time as a result of reduced liability, materials losses, etc.)	¼% to 2% increase in staff time (based on 240 workdays per year).

3.5.1 P2 Removal Effectiveness

For the Motor Vehicle Parts Sector, it was expected that the most effective Elimination/Reduction P2 measure would be implemented for each substance of concern. In addition, it was assumed that all applicable measures in the Operating Procedures and Housekeeping group of BMPs and all applicable measures in the Education and Training group of BMPs would also be implemented.

The most effective Elimination/Reduction P2 measures for cadmium and NPE are as follows:

- Cadmium: Reduce Drag-out BMP #4 and Material Substitution for Cadmium plating-BMP #8.
- NPE: Material Substitution for NPE containing cleaning products, surface preparations and metal processing products BMPs #11 and #12.

Effectiveness of materials substitution for cadmium is estimated to be 50-75%, based on rules of thumb developed for application where no specific industry data was available. To reach the least stringent reference criteria, the BMP for drag-out reduction could be utilized as opposed to substitution to achieve the desired reduction. A reduction of 75% was assumed for cadmium. Effectiveness for materials reduction for nonylphenol and NPE is assumed to be 62.5% removal, based on rules of thumb developed for applications where no specific industry data was available.

Applicable Operating Procedures and Housekeeping BMPs are:

- Contain all above-ground tanks containing liquids whose spillage could be harmful to the environment - BMP #13.
- Effective operational and maintenance systems - BMP #14.
- Accident Prevention - BMP #17.

The effectiveness of Operating Procedures and Housekeeping is estimated to be 20% removal of the remaining contaminants after materials substitution/process modifications (i.e., the mid-range of expected effectiveness of this group of BMPs). In the case of cadmium, Operating Procedures and Housekeeping are assumed to remove 20% of the remaining 25% of contaminants, for an additional 5% net reduction in cadmium prior to treatment. Therefore, with the combination of substance substitution/process modifications and operating procedures and housekeeping, a cumulative removal of 80% of cadmium in the wastewater effluent from motor vehicle parts manufacturing facilities is estimated.

For NPE, Operating Procedures and Housekeeping are estimated to remove 20% of the remaining 37.5 % of the remaining concentration, for an additional 7.5 % net reduction in NPE concentration in the wastewater effluent from motor vehicle parts manufacturing facilities, prior to treatment. Therefore, with the combination of

substance substitution/process modifications and operating procedures and housekeeping, a cumulative removal of 70% of NPE in the wastewater effluent from motor vehicle parts manufacturing facilities is estimated.

The effectiveness of Education and Training practices in removing NPE is estimated to be 2% removal of the remaining contaminants after materials substitution, process modifications and operating and housekeeping practices. This effectiveness rate is at the low end of the rules of thumb range for the Motor Vehicle Parts Manufacturing Sector (Table 3.2) due to the fact that the staff and supply chain should be already familiar with issues associated with NPE.

Education and Training is an integral component of a comprehensive pollution prevention program and is needed to ensure the success of the other recommended BMPs. The combination of substance substitution/process modifications, operating procedures and housekeeping, and education/training in the wastewater effluent from motor vehicle parts manufacturing facilities is estimated to result in a cumulative removal of 70% of NPE.

For cadmium, Education and Training practices are estimated to remove 20% of the remaining 25% present in wastewater effluent, for an additional 5% removal. Therefore, the combination of substance substitution/process modifications, operating procedures and housekeeping, and education/training in the wastewater effluent from motor vehicle parts manufacturing facilities is estimated to result in a cumulative removal of 80% of cadmium.

In summary, the effectiveness of P2 BMPs in achieving reductions of the pollutants examined is estimated to be approximately 80% removal of cadmium and 70% removal of NPE prior to treatment. Table 3.4 provides a summary of the estimated effectiveness discussed in this section. Refer to Tables 5.1 to 5.3 (Section 5) for a summary of P2 BMP effectiveness and treatment measures to achieve the reference criteria.

Table 3.4 Summary of Effectiveness of BMPs

Substance Addressed	BMP Name	BMP Number
Elimination/ Reduction Effectiveness: 50-75%		
Cadmium	Drag-out reduction	BMP #4
Cadmium	Material Substitution for Cadmium plating	BMP #8
NPE	Material Substitution for NPE containing cleaning products	BMP#11
NPE	Material Substitution for NPE containing surface preparations and metal processing products	BMP #12
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
Cadmium & NPE	Contain all above-ground tanks containing liquids whose spillage could be harmful to the environment	BMP #13
Cadmium & NPE	Effective operational and maintenance systems	BMP #14
Cadmium & NPE	Accident Prevention	BMP #17
Education & Training Effectiveness: 5 % for Cadmium, 2 % for NPE		
Cadmium & NPE	Management and Staff Training	BMP #18

3.5.2 P2 Costs

Acquisition costs for materials substitutions (i.e., once an acceptable substitute has been identified and selected for use) may be considered negligible for all sizes of facility, given relatively small materials cost impacts and positive indirect benefits, such as reduced hazardous materials handling, for specific substitution applications only. Where a facility is highly automated, material cost may be more significant than staff costs. Note that where a product is reformulated to eliminate a particular substance (as opposed to a direct substitution), significant research and development costs may be incurred. Estimation of these costs is product-specific and not considered to be within the scope of this general BMP. Site specific evaluation of the particular plant or manufacturing facility's process requirements and of the potential for cost-effective substitution, planning, product re-formulation etc., are some of the necessary steps in defining the substitution requirements, the feasibility of substitution and associated costs.

Costs associated with implementation of the process modification BMPs are expected to have annualized capital costs between $1k-5k as well as the cost associated with equivalent staff estimates between ¼ to 5 person years per modification. However, process modifications which involve drag out reductions are expected to be at the lower end of the range established for capital and operating costs. Drag out often involves minimal, if any, infrastructure changes requiring

capital and a limited amount of labour. Assuming the low range of the cost estimates, costs are estimated for the implementation of Pollution Elimination or Reduction for all three facility sizes for cadmium only. Products produced will not be adversely affected by implementation of BMPs.

For purposes of determining the possible costs that may be required to achieve elimination through substitution or reduction through process modification (as a combined cost estimate), the cost estimation procedure used to determine process modification costs has been considered to also include budget allocation for substitution.

In addition, various positive indirect benefits, such as reduced hazardous materials handling costs and reduced costs from worker health and safety claims due to cadmium exposure can be anticipated.

Costs associated with implementation of Operating Procedures and Housekeeping BMPs are assumed to be proportional to staff complement and to cost between 1/2% and 5% of the staff budget. The upper end of this range would be applicable to facilities without well-established operating procedures and record-keeping practices. Assuming mid-range of the cost estimates, costs are estimated for implementation of the Operating Procedures and Housekeeping BMPs for three facility sizes for both substances.

Costs associated with implementation of Education and Training BMPs are expected to be proportional to staff complement and to cost between ¼% and 2% of the staff budget. The upper end of this range would be applicable to facilities without well-established training programs. The cost estimates adopt the mid-range of the rule of thumb range.

Estimated costs for implementation of the P2 BMPs are summarized in Table 3.5. Clearly, these estimates constitute a first-cut high-level estimate in the absence of facility-specific data and circumstances:

Table 3.5 Estimated Pollution Prevention Costs (for selected P2 BMPs)

Type of P2 Measure	**Pollution Prevention Annual Costs***		
	Small Facilities (25 Staff)	**Medium Facilities (175 Staff)**	**Large Facilities (300 staff)**
Pollution Elimination or Reduction	$16,300	$17,305	$19,200
Operating/ Housekeeping	$20,000	$160,000	$270,000
Education/Training	$8,000	$65,000	$110,000
Total Estimate	$44,300	$242,305	$399,200

Note:
* Estimated annual costs for each P2 measure are approximations only; facility specific wastewater quality and operating practices must be assessed prior to selection of P2 practices.

4. TREATMENT

Treatment is not a P2 measure and it is not as effective as P2 in preventing the release of hazardous substances since it occurs after the hazardous substance has been used or created and subsequently becomes part of the facility's wastewater. With some treatment, the hazardous substance may be simply transferred from the water to the air or the sludge. Operating and capital costs of treatment can be significant. As a result, treatment should only be considered after P2 measures have been implemented and after all efforts have been taken to reduce or eliminate the substance first through P2 practices.

4.1 Treatment Measures

Treatment measures and BMPs must be assessed and implemented based on specific site and process conditions and characteristics. The following subsections present treatment processes to be considered where P2 alone does not meet the reference criteria.

The reference criteria outlined in Section 2.2 are provided for the purpose of assessing the potential for application of select treatment technologies for the select substances identified in this BMP document.

The following subsections provide a brief overview of typical treatment systems for cadmium and nonylphenol and its ethoxylates. The processes described were based on estimated wastewater constituents for the motor vehicle parts manufacturing sector. The treatment review was based on representative wastewater data available for this sector.[36] Other treatment processes may be more applicable at facilities that have a wastewater stream significantly different from that used in this assessment.

4.1.1 Treatment Measures for Nonylphenol and its Ethoxylates

Four types of treatment processes are potentially applicable to meet the reference criteria for NPE outlined in Section 2.2. The treatment processes provided are presented in sequential order of treatment requirements, with the process required to achieve the lowest concentration presented last. These treatment processes can be used alone or in combination, depending on specific wastewater properties.

- **Aerobic biological treatment:** Biological treatment involves contacting wastewater with a microbial reactor to remove biodegradable organic pollutants. The microorganisms convert the organic material into new microbial cells, which results in a sludge that requires disposal. Aerobic biological treatment involves adding air to the process to facilitate aerobic biodegradation, which is the process required for the contaminants of concern. Treatment can be either a suspended biomass system (such as activated sludge) or an attached growth system (e.g., trickling filters, rotating

[36] Refer to Section 2.1.

biological contactors). Both types of systems require a clarification process after the bioreactor. This process requires specific environmental control to operate effectively, e.g., sufficient aeration and a limited pH range. There are limited data available for the effectiveness of biological treatment to remove NPE; therefore, pilot testing of wastewater is recommended.

- **Granular activated carbon (GAC) or powdered activated carbon (PAC):** The GAC process involves pumping wastewater through a fixed-bed column containing GAC granules. The GAC adsorbs pollutants from the wastewater. A two-stage system may be required to reduce the concentration to below the concentrations required to meet the reference criteria. The spent GAC is regenerated off-site. The type of pollutants adsorbed and the extent of adsorption are a function of the source material for the GAC and the preparation procedure for the GAC granules. Typically, a sand filter or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter. As an alternative to GAC, PAC can be added to the bioreactor of an activated sludge biological treatment system. PAC cannot be regenerated and is disposed of as a waste with the biological treatment sludge. There are limited data on the removal efficiency of GAC or PAC for NPE; therefore, pilot testing is recommended for these processes.

- **Reverse osmosis (RO):** RO processes can be used as a polishing stage to further reduce the concentration of some organics, including NPE. Sand or mixed media filtration followed by microfiltration is typically used as a pre-treatment stage. The RO process separates water from dissolved materials and some organics in solution by filtering through a semipermeable membrane under pressure. The basic components of an RO system are the membrane, a membrane support structure, a containing vessel, and a high-pressure pump. The permeability of the membrane used, level of wastewater pre-treatment and membrane cleaning are the key criteria for the performance of this process. RO results in a waste stream, or reject, that must be disposed of.

- **Advanced Oxidation (AOT):** AOT can be used to further reduce the concentration of NPE after RO treatment, if required. The AOT process uses ultraviolet (UV) light in conjunction with an oxidant such as ozone or hydrogen peroxide. This combination achieves a significantly greater treatment performance that using the oxidant alone. UV light is used to split the oxidant molecule, producing very reactive hydroxyl radicals. These hydroxyl radicals react quickly with organic pollutants in the water, breaking them down into carbon dioxide and water. The treatment process will break down any organic contaminant; therefore, to treat the relatively low levels of the organic contaminants of concern, the removal of other organics will typically be required before this process is used.

Biological treatment will typically be required as a preliminary treatment stage before GAC treatment when the concentration of organic compounds in the

wastewater [measured as 5-day biochemical oxygen demand (BOD_5)] is greater than 100 mg/L. For wastewater streams that have a relatively low BOD_5, GAC will be the most cost-effective treatment option. Due to the estimated high influent levels of NPE for this sector, further removal of NPE by RO may be required after biological and/or GAC treatment. In some instances AOT may be required to achieve the concentrations required for Reference Criteria 1.

4.1.2 Treatment Measures for Cadmium

Three types of treatment processes are potentially applicable to meet the reference criteria for cadmium outlined in Section 2.2. The treatment processes provided are presented in sequential order of treatment requirements, with the process required to achieve the lowest concentration presented last. These treatment processes can be used alone or in combination, depending on specific wastewater properties.

- **Chemical precipitation:** Cadmium can be precipitated as insoluble cadmium hydroxide by pH adjustment. The precipitated metal is removed from the wastewater stream by settlement. Filtration using a sand or mixed media filter may be used after settlement to further reduce the concentration. It is assumed that chemical precipitation and settlement is in place for facilities with raw wastewater cadmium concentrations in excess of the sewer use by-law limit. Therefore, this treatment stage was not included in the cost assessment for cadmium removal. It is important to note that some cadmium may accumulate in the sludge of a biological treatment system, which could be released during sludge treatment. Therefore, facilities using a biological treatment system should chemically precipitate cadmium before biological treatment to minimize cadmium accumulation in biological sludge.

- **Granular activated carbon (GAC):** GAC is not a conventional treatment option for cadmium as the removal efficiency is relatively low (around 30%). However, if a GAC process is used to remove organic pollutants, such as NPE, there will also be some reduction in the cadmium concentration. The GAC process involves pumping wastewater through a fixed-bed column containing GAC granules. The GAC adsorbs pollutants from the wastewater. The spent GAC is regenerated off-site. The type of pollutants adsorbed and the extent of adsorption are a function of the source material for the GAC and the preparation procedure for the GAC granules. Typically, a sand filter or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter.

- **Reverse osmosis (RO) or Deionization (DI):** RO or DI processes can be used as a polishing stage to further reduce the concentration of cadmium. Filtration using a sand or mixed media filter followed by microfiltration is typically required as a pre-treatment stage. The RO process separates water from dissolved materials in solution by filtering through a semipermeable membrane under pressure. The basic components of an RO system are the membrane, a membrane support structure, a containing vessel, and a high-

pressure pump. The permeability of the membrane used, level of wastewater pre-treatment and membrane cleaning are the key criteria for the performance of this process. RO results in a waste stream, or reject, that must be disposed of. For the DI process, specific ions are displaced from an insoluble exchange material (or resin) by different ions in solution. The spent resin is regenerated and reused. The waste stream from regeneration must be disposed of. The type of resin, level of wastewater pre-treatment and frequency of regeneration are the key criteria for effectiveness of treatment for DI.

4.2 Treatment Options and Costs

Treatability information is provided for the individual pollutants specified in Tables 5.1 to 5.3 as a guide (Section 5). Based on the estimated wastewater concentrations of NPE and cadmium after P2 measures that are provided in the tables, assuming wastewater BOD_5 is less than 100 mg/L[37], and assuming the reduction or removal of NPE and cadmium, the overall treatment systems in terms of sequential process steps for each reference criteria are as follows:

- Reference Criteria 1: Chemical precipitation, sand/mixed media filtration, GAC, microfiltration, RO, and DI;
- Reference Criteria 2: Chemical precipitation, sand/mixed media filtration, GAC, microfiltration, and DI; and
- Reference Criteria 3: Chemical precipitation, sand/mixed media filtration, and GAC.

The GAC and RO treatment processes are required for the removal of NPE to meet Reference Criteria 1, whereas GAC alone would be suitable to remove NPE to meet Reference Criteria 2 and 3. For cadmium, DI is required to meet Reference Criteria 1 and 2, but is not required for Reference Criteria 3. Some cadmium removal will be provided by GAC. Chemical precipitation is required for cadmium for all reference criteria and serves as pre-treatment for the additional treatment required to meet Reference Criteria 1 and 2. If it is assumed that a chemical precipitation system is already in place, then no further additional treatment will be required for cadmium to meet Reference Criteria 3.

The proposed treatment strategies identified above serve as preliminary guidelines for the full level of treatment likely to be required. Different treatment options may be required, depending on the wastewater constituents and strength. For example, it is possible that cadmium could be eliminated through aggressive P2 measures, which would eliminate the requirement for DI for Reference Criteria 1 and 2. There may also be some site-specific cases where RO is a better option than DI for cadmium removal, where required.

[37] Should BOD_5 concentrations after P2 measures but before treatment be higher than 100 mg/L, additional treatment, such as biological treatment for NPE removal, may be required.

Site and facility specific information is needed to determine what treatment trains and components are required to achieve the reference criteria. A typical total treatment process for motor vehicle parts manufacturing sector wastewater after P2 measures will provide treatment for all pollutants identified in the wastewater. A comprehensive analysis of the wastewater stream is required and bench-scale and/or pilot testing of treatment may be needed to verify the optimum treatment system for a specific facility.

Capital and operational and maintenance (O&M) cost curves were developed for the full treatment requirements for the motor vehicles parts manufacturing sector, as above indicated, for all identified substances in order to meet the three reference criteria using a wastewater flow range of 1 m^3/h to 50 m^3/h. The estimated costs are presented in Table 4.1.

Costs were also developed for an alternative treatment scenario where cadmium is significantly reduced or eliminated through P2 measures to sufficiently low levels whereby DI would not be required for Reference Criteria 1 and 2. Table 4.1 includes this alternative treatment scenario.

The costs provided in Table 4.1 are conceptual level only, normally considered to be accurate to a range of –35% to + 50%.

Table 4.1 Estimated Capital and Annual Operation and Maintenance Costs

Reference Criteria	**Approximate Costs as Function of Flow Range of 1 to 50 m^3/h***					
	Capital Cost Range			**Annual O&M Cost Range**		
	1m^3/h	**25 m^3/h**	**50 m^3/h**	**1m^3/h**	**25 m^3/h**	**50 m^3/h**
Full Treatment						
Criteria 1	$302,000	$2,484,000	$4,060,000	$45,000	$298,000	$406,000
Criteria 2	$258,000	$1,173,000	$2,101,000	$39,000	$141,000	$210,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Treatment Assuming Low Cadmium Levels (i.e., no DI)						
Criteria 1	$127,000	$1,772,000	$2,777,000	$19,000	$213,000	$278,000
Criteria 2	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000

Note:
* Refer to Figures 4.1 to 4.3 for capital and O&M costing curves to estimate full treatment costs for a specific flow rate. Costs exclude chemical precipitation (metals removal), which is assumed to be installed. If required, the following estimated capital costs should be added: 1 m^3/hr = $67,200; 25 m^3/hr = $371,000; 50 m^3/hr = $658,000. The corresponding annual operations and maintenance (O&M) costs for a chemical precipitation system are $10,000, $45,000 and $66,000 respectively for system sizes of 1 m^3/hr, 25 m^3/hr and 50 m^3/hr.

The capital costs presented in Table 4.1 do not include chemical precipitation for metals pre-treatment and removal, as it is assumed that this would be a treatment

process already installed and operating. Should a particular plant or facility not have a chemical precipitation system installed, then the capital costs should be increased accordingly, as shown in Table 4.1. Costing includes engineering, equipment, piping and instrumentation, electrical and controls, installation, and construction costs. Treatment costs assume the combined reduction or removal of NPE and cadmium. Of these substances, cadmium is considered to require the highest level of treatment to meet the requirements of Reference Criteria 1.

The annual O&M costs were determined as a function of percentage of capital costs, assuming 15% for the 1 m^3/h flow condition, 12% for the intermediate 25 m^3/h flow condition, and 10% for the 50 m^3/h flow condition. Annual O&M costs include a consideration of the following:

- Increased power and energy costs to operate the additional treatment processes;
- Chemical costs for treatment chemicals, where required;
- Additional labour costs for operation;
- Sampling and monitoring costs for the specific substances requiring treatment; and
- Disposal costs for residues and waste streams generated from treatment.

Figures 4.1 to 4.3 show capital and annual O&M costing curves for the estimated full treatment cost ranges presented in Table 4.1 for each set of reference criteria.

Figure 4.1 Motor Vehicle Parts Manufacturing Sector Capital and O&M Costs for Reference Criteria 1

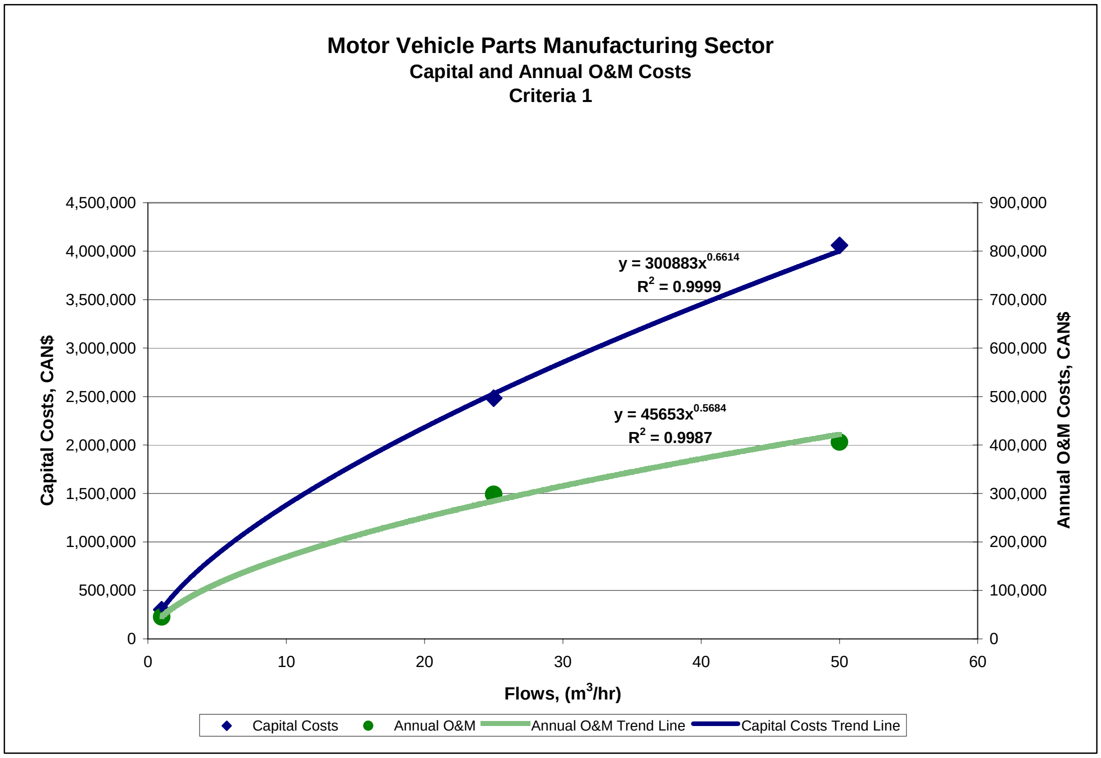


Figure 4.2 Motor Vehicle Parts Manufacturing Sector Capital and O&M Costs for Reference Criteria 2

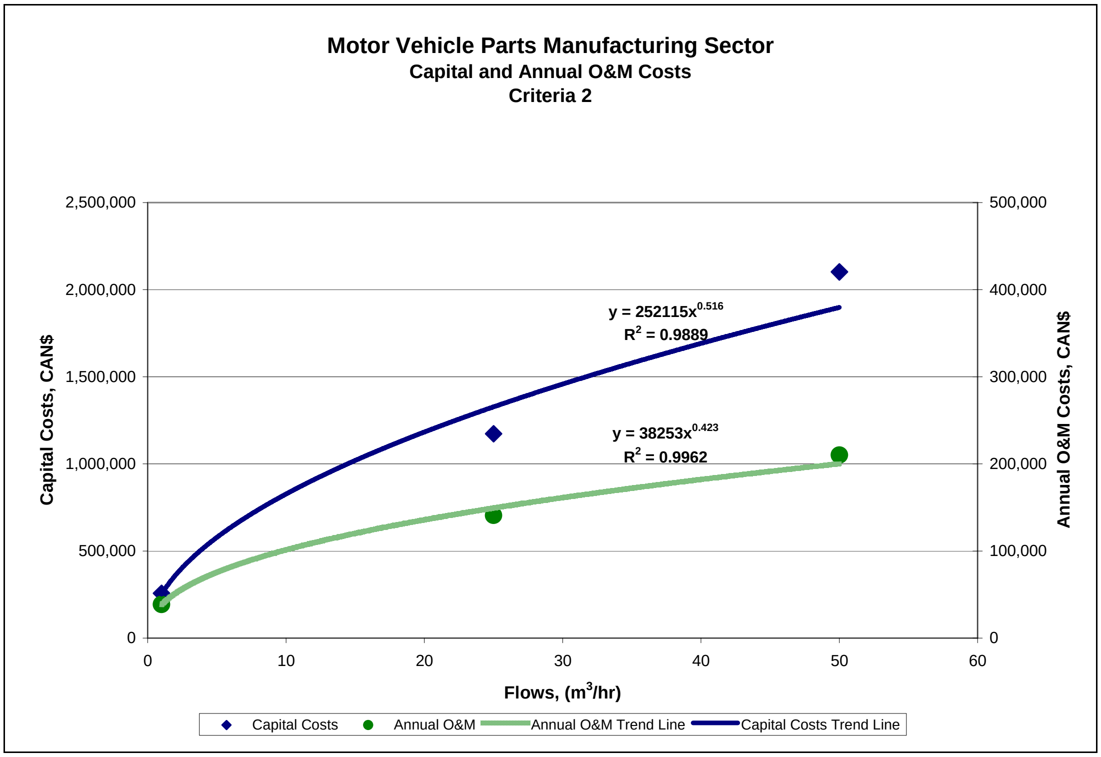
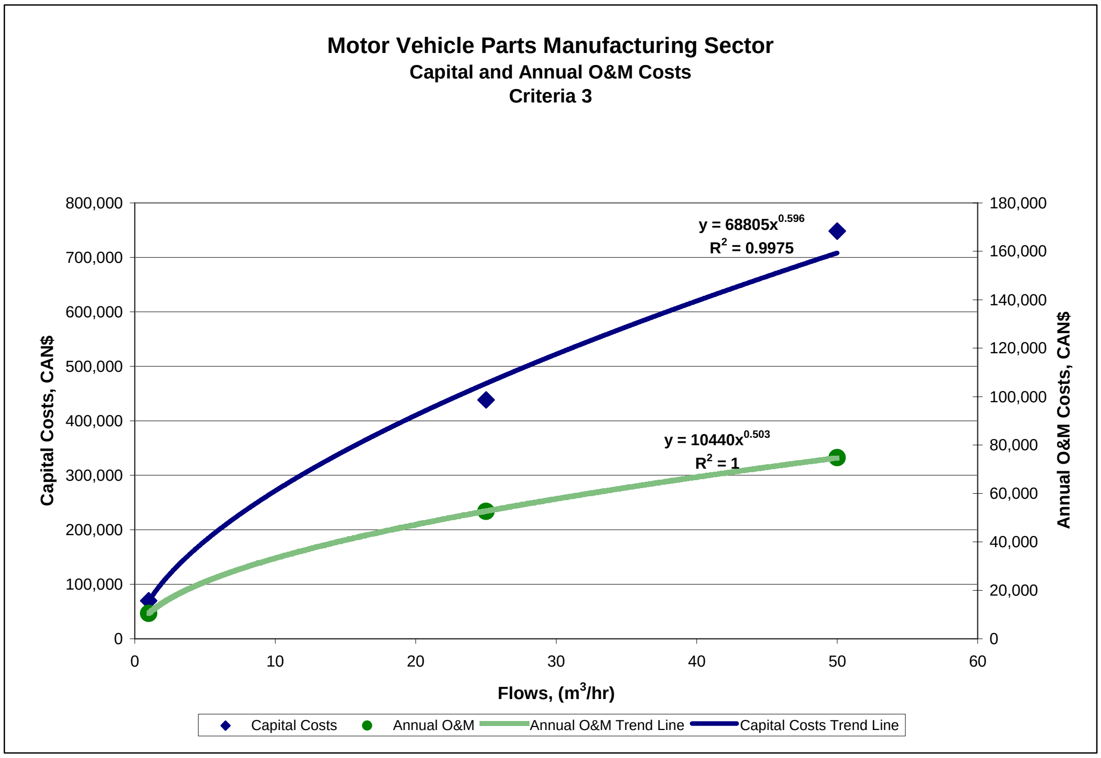


Figure 4.3 Motor Vehicle Parts Manufacturing Sector Capital and O&M Costs for Reference Criteria 3



5. OPTIONS FOR REDUCTION OF SUBSTANCE CONCENTRATIONS IN EFFLUENTS

The following tables outline the combination of P2 measures and treatment evaluated for substance removal effectiveness. These measures were chosen on the basis of ability to achieve the reference criteria, costs, and feasibility for implementation.

Based on the estimating procedures used to determine initial concentrations and percent removal resulting from implementation of P2 measures, no reference criteria were estimated to be met with P2 alone (i.e., no additional treatment required). Cadmium can meet Reference Criteria 3 with chemical precipitation and additional treatment may not be required if a chemical precipitation system is already installed. Additional treatment, nevertheless, is required for cadmium to meet Reference Criteria 1 and 2.

Depending on the actual initial concentrations and percent removal resulting from implementation of P2 measures and assuming more aggressive source reduction of NPE and cadmium, there may be the possibility to reduce the levels of treatment required and possibly meet some reference criteria through P2 measures only.

Site and facility specific analysis of the wastewater stream is required to determine which pollutants can be reduced to the reference criteria by implementation of P2 measures.

Information provided in the tables is based on assumptions for the concentration of each substance in wastewater before and after P2 measures. Treatability information is also based on estimated removal rates for treatment processes. A detailed analysis of the waste streams and the wastewater would be required for each facility to determine the optimum treatment system should this be required after P2 implementation.

Table 5.1 Summary: Cadmium

Reference Criteria	Assumed Concentration Prior to Implementation of Measures[1]	P2 Measures	Estimated % Removal Resulting from P2 Measures[2]	Concentration After P2 Measures	Treatment Measures	Estimated % Removal Resulting from Combined Treatment Measures	Estimated Concentration of Substance in Effluent after Combined Measures
Reference Criteria 1 0.0006 mg/L	10 mg/L	Material Substitution (75%) Operating Procedures & Housekeeping (20%) Education and Training (5%)	80%	2 mg/L	Chemical Precipitation[8], Filtration[3], GAC[4], Microfiltration[5], RO[6] and DI[7]	99.998%	0.00004 mg/L
Reference Criteria 2 0.02 mg/L	10 mg/L	Material Substitution (75%) Operating Procedures & Housekeeping (20%) Education and Training (5%)	80%	2 mg/L	Chemical Precipitation[8], Filtration, GAC, Microfiltration and DI	99.965%	0.0007 mg/L
Reference Criteria 3 1 mg/L	10 mg/L	Material Substitution (75%) Operating Procedures & Housekeeping (20%) Education and Training (5%)	80%	2 mg/L	Chemical precipitation[8]	50%	1 mg/L

[1] Initial concentrations are summarized in Section 2.1 Table 2.1. Limited plant data available for cadmium concentrations for automotive parts sector. Concentration shown is based on estimates from available data for the fabricated metal products sector.
[2] Total percent removal is calculated as follows: 0.75 + (1-0.75)(0.2) + (1-0.75)(0.05) = 0.8 or 80% removed.
[3] Filtration using a sand or mixed media filter is typically required as a pretreatment stage for GAC
[4] Estimated removal of 30%. GAC is typically not used as a treatment process for cadmium, but will get some removal of cadmium if this process is used for removal of organic substances
[5] Typically required as a pretreatment stage for RO and DI
[6] Estimated removal of 95%
[7] Estimated removal of 99.9%
[8] Estimated minimum removal rate of 50% as need to achieve Reference Criteria 3. Higher performance can typically be achieved.

Table 5.2 Summary: Nonylphenol Ethoxylates

Reference Criteria	Assumed Concentration Prior to Implementation of Measures[1]	P2 Measures	Estimated % Removal Resulting from P2 Measures[2]	Concentration After P2 Measures	Treatment Measures	Estimated % Removal Resulting from Combined Treatment Measures	Estimated Concentration of Substance in Effluent after Combined Measures
Reference Criteria 1 0.001 mg/L	2.3 mg/L[3]	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.69 mg/L	Filtration[4], GAC[5], Microfiltration[6] and RO[7]	99.9%	0.00069 mg/L
Reference Criteria 2 0.01 mg/L	2.3 mg/L	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.69 mg/L	Filtration and GAC	99.5%	0.00345 mg/L
Reference Criteria 3 0.025 mg/L	2.3 mg/L	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.69 mg/L	Filtration and GAC	99.5%	0.00345 mg/L

[1] Initial concentrations are summarized in Section 2.1 Table 2.1.
[2] Total percent removal is calculated as follows: 0.625 + (1-0.625)(0.20) + (1-0.625)(0.02) = 0.7 or 70% removed.
[3] Limited plant data available for nonylphenol concentrations for automotive parts sector. Concentration shown is based on estimates from available data for the chemical manufacturing sector.
[4] Filtration using a sand or mixed media filter is typically required as a pretreatment stage for GAC
[5] Estimated removal of 99.5%
[6] Typically required as a pretreatment stage for RO
[7] Estimated removal of 80% as needed to achieve better than Reference Criteria 1 requirements

Table 5.3 Summary: Nonylphenol

Reference Criteria	Assumed Concentration Prior to Implementation of Measures[1]	P2 Measures	Estimated % Removal Resulting from P2 Measures[2]	Concentration After P2 Measures	Treatment Measures	Estimated % Removal Resulting from Treatment Measures	Estimated Concentration of Substance in Effluent after Combined Measures
Reference Criteria 1 0.001 mg/L	0.15 mg/L[3]	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.045 mg/L	Filtration[4] and GAC	99.5%	0.000225 mg/L
Reference Criteria 2 0.001 mg/L	0.15 mg/L	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.045 mg/L	Filtration and GAC	99.5%	0.000225 mg/L
Reference Criteria 3 0.0025 mg/L	0.15 mg/L	Material Substitution (62.5%) Operating Procedures& Housekeeping (20%) Education and Training (2%)	70%	0.045 mg/L	Filtration and GAC	99.5%	0.000225 mg/L

[1] Initial concentrations are summarized in Section 2.1 Table 2.1.
[2] Total percent removal is calculated as follows: 0.625 + (1-0.625)(0.20) + (1-0.625)(0.02) = 0.7 or 70% removed.
[3] Limited plant data available for nonylphenol concentrations for automotive parts sector. Concentration shown is based on estimates from available data for the chemical manufacturing sector.
[4] Filtration using a sand or mixed media filter is typically required as a pretreatment stage for GAC.

6. KEY REFERENCES

The following documents were key in preparing this BMP:

1. Bray, Andy. (March 2001). *Pollution Prevention in Machining and Metal Fabrication: A Manual for Technical Assistance Providers*. Available at URL: http://www.newmoa.org/Newmoa/htdocs/prevention/topichub/23/NEWMOAmanual.pdf

2. Department of Planning and Environmental Protection, Pollution Prevention and Remediation Programs – Broward County. (n.d.). *Pollution Prevention and Best Management Practices for Metal Finishing Facilities.* Available at URL: http://www.co.broward.fl.us/ppi00500.htm

3. Environment Agency. (2004). *Guidance for the Surface Treatment of Metals and Plastics by Electrolytic and Chemical Processes.* Bristol, United Kingdom: Environment Agency.

4. Garruto, Mike. (September 1996). *An Analysis of Pollution Prevention Opportunities and Impediments in the Fabricated Metal Products Manufacturing Sector in Georgia*. Available at URL: http://www.p2ad.org/Assets/Documents/ma_fabmetal.htm

5. Illinois Waste Management and Research Centre. (n.d.). *Metal Finishing Industry Pollution Prevention Notebook.* Available at URL: http://www.wmrc.uiuc.edu/main_sections/info_services/library_docs/manuals/finishing/toc1.htm

6. National Center for Manufacturing Sciences. (1994). *Blue Book: Pollution Prevention Control Technologies for Plating Operations*. Available at URL: http://www.nmfrc.org/bluebook/tocmain.htm

7. Risk and Policy Analysts. (September 2000). Prepared for Department of the Environment, Transport and the Regions (UK). *Nonylphenol Risk Reduction Strategy*. Available at URL: http://www.rpaltd.co.uk/tools/downloads/reports/nonylphenol.pdf

8. US Environmental Protection Agency: Compliance Assistance and Sector Programs Division. (1995). *Profile of the Motor Vehicle Assembly Industry EPA Sector Notebook*. Available at URL: http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/motor.html

7. GLOSSARY OF TERMS

Best Management Practices (BMPs) to reduce or eliminate pollutants encompass a wide range of activities including changes to materials or processes, operating procedures, housekeeping activities, and treatment techniques. BMPs may also include management activities, such as education and training, record-keeping and reporting, information systems, and communication with stakeholders, customers, and supply chain partners. BMPs can also include management approaches such as loss control programs and environmental management systems.

Canadian Environmental Protection Act 1999 (CEPA 1999) is federal legislation that was first created in 1988 and consolidated various pieces of 1970s environmental legislation.[38] In addition, CEPA 1999 added many new Ministerial authorities and obligations, including new requirements for risk assessment and risk management of toxic substances and a strengthened pollution prevention approach.

Criteria are the reference criteria identified for analysis. There are three reference criteria, with Reference Criteria 1 being the most stringent and Reference Criteria 3 the least stringent.

Environmental Management System (EMS)[39] refers to management systems focussed on the minimization of harmful effects on the environment caused by corporate activities. Management systems in general are part of an organization's structure for managing its processes or activities that transform inputs of resources into a product or service, which meet the organization's objectives, such as satisfying the customer's quality requirements, complying with regulations, or meeting environmental objectives. Environmental management is what the organization does to minimize harmful effects and to achieve continual improvement of its environmental performance.

Hazardous Substances refers to substances that are potentially harmful to the environment or human health and safety. Hazardous substances include substances considered toxic under the Canadian Environmental Protection Act 1999, as well as other substances of interest subject to international agreement and reporting requirements. Refer to the Appendices for a list of substances of particular interest in this series of BMP documents.

Industrial Facility Representatives may include any industrial employee or contractor of an industrial sector with responsibility, for example, for facility operations, facility design, public relations, compliance.

National Pollution Release Inventory (NPRI) is a database of information on annual releases to air, water, land, and disposal or recycling from all sectors -

[38] Refer to the CEPA 1999 Environmental Registry for more information at URL: http://www.ec.gc.ca/CEPARegistry/default.cfm

[39] Definition adapted from definitions by the International Organization for Standardization, URL: http://www.iso.org/iso/en/iso9000-14000/understand/inbrief.html

industrial, government, commercial, and others.[40] The NPRI is a national reporting system legislated under the Canadian Environmental Protection Act 1999.

Municipal Representatives may include any municipal employee or contractor with responsibility, for example, wastewater quality, wastewater infrastructure management, industrial sewer use programs, industrial relations, public outreach, and/or by-law enforcement.

NAICS Code is the North American Industry Classification System (NAICS), which assigns numerical codes to industrial sectors and sub-sectors in North America. This system has replaced an older system of classification, known as the U.S. Standard Industrial Classification (SIC) system. Statistics Canada uses the NAICS classification system in its analysis of industrial activities in Canada.

Pollution Prevention (P2) is "the use of processes, practices, materials, products, substances or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to the environment or human health."[41]

Reference Criteria are the maximum desired final effluent concentrations for the harmful substances identified. Three reference criteria were identified for analysis in terms of pollution prevention measures and treatment measures required to achieve the reference criteria.

Rules of Thumb are sets of engineering estimates based on similar or related datasets, professional judgement, and stated assumptions. Rules of Thumb are applied where specific information is not available. In the absence of specific information, Rules of Thumb can be used to develop reasonable ranges of potential outcomes or effects resulting from actions taken (such as implementation of certain P2 or treatment measures, for example).

Substances of Interest are the potentially hazardous substances or toxic substances examined within this series of best management practices. Refer to the Appendices for a list of substances of particular interest in this series of BMP documents.

Supply Chain refers to the network of organizations that provide materials, products, and services to industrial sectors in order that the industry can produce, market, and sell its products. The supply chain can include organizations selling raw materials, organizations selling semi-finished and finished goods, retail outlets, customers, etc.

Treatment in this document refers to wastewater treatment processes used to remove or transform pollutants in the wastewater stream. Treatment is not

[40] See the NPRI website at URL: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

[41] Definition in Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the *Canadian Environmental Protection Act*, 1999 (CEPA 1999), National Office of Pollution Prevention, Environment Canada, 2001

considered a pollution prevention measure since it occurs after pollutants have been introduced or used in a process; pollutants that are present in a wastewater stream indicate that opportunities to prevent pollution have passed and treatment must therefore be used to reduce release of the pollutants to the environment.

APPENDIX A

BEST MANAGEMENT PRACTICES DOCUMENTS

APPENDIX A: BEST MANAGEMENT PRACTICES DOCUMENTS

Table A.1 identifies the available Best Management Practices Documents in this series, and the industrial sectors and harmful pollutants which are addressed in each.

Table A.1 Industrial Sectors and Substances Addressed in BMP Documents

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Textiles Sector: Nonylphenol and its Ethoxylates and Chromium	Textiles Sector (313) Fibre, Yarn, Thread Mills Fabric Mills Textile and Fabric Finishing and Fabric coating	Nonylphenol and its ethoxylates Chromium
Best Management Practices. Fabricated Metal Product Manufacturing: Cadmium, Lead and Copper	Fabricated Metal Product Manufacturing (332) Forging and Stamping Architectural and Structural Metals Manufacturing Boiler, Tank and Shipping Container Manufacturing Spring and Wire Product Manufacturing Coating, Engraving, Heat Treating and Allied Activities Other Fabricated Metal Product Manufacturing	Cadmium Lead Copper
Best Management Practices. Motor Vehicle Parts Manufacturing: Cadmium and Nonylphenol and its Ethoxylates	Motor Vehicle Parts Manufacturing (3363) Motor Vehicle Gasoline Engine and Engine Parts Manufacturing Motor Vehicle Electrical and Electronic Equipment Manufacturing Motor Vehicle Metal Stamping Motor Vehicle Steering and Suspension Components (except Spring)Manufacturing Motor Vehicle Brake System Manufacturing Motor Vehicle Transmission and Power Train Parts Manufacturing	Cadmium Nonylphenol and its ethoxylates

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Automotive Repair and Maintenance: Cadmium and PAHs	Automotive Repair and Maintenance (8111) Automotive Repair and Maintenance Automotive Body, Paint and Interior Repair and Maintenance Car Washes	Cadmium PAHs
Best Management Practices. Dry Cleaning and Laundry Services: Nonylphenol and its Ethoxylates, Cadmium, and Mercury	Dry Cleaning and Laundry Services (8123) Dry Cleaning and Laundry Services (except Coin-Operated) Linen and Uniform Supply	Nonylphenol and its ethoxylates Cadmium Mercury
Best Management Practices. Chemical Manufacturing Sector: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride	Chemical Manufacturing Sector (325) Basic Chemical Manufacturing (NAICS 3251); Pharmaceutical and Medicine Manufacturing (NAICS 3254); Soap, Cleaning Compound and Toilet Preparation Manufacturing (NAICS 3256) Other Chemical Product Manufacturing (NAICS 3257)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates Vinyl chloride
Best Management Practices. Chemical Manufacturing Sector: Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride	Chemical Manufacturing Sector (325) Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing (NAICS 3252)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates Vinyl chloride

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Chemical Manufacturing Sector: Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, and Nonylphenol and its Ethoxylates	Chemical Manufacturing Sector (325) Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing (NAICS 3253)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates
Best Management Practices. Chemical Manufacturing Sector: Paint, Coating, and Adhesive Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, and Nonylphenol and its Ethoxylates	Chemical Manufacturing Sector (325) Paint, Coating, and Adhesive Manufacturing (NAICS 3255)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates
Best Management Practices. 1,4-Dichlorobenzene, 3,3-Dichlorobenzidine, Hexachlorobenzene, and Pentachlorophenol: Non-Sector Specific Practices	Not applicable.	1,4-Dichlorobenzene 3,3-Dichlorobenzidine Hexachlorobenzene Pentachlorophenol

APPENDIX B

SUB-SECTOR DEFINITIONS

APPENDIX B – SUB-SECTOR DEFINITIONS

Definitions for the motor vehicle parts manufacturing sub-sectors are as follows: [42]

- Motor Vehicle Gasoline Engine and Engine Parts Manufacturing (NAICS 33631).

  This industry comprises establishments primarily engaged in manufacturing and rebuilding motor vehicle gasoline engines and engine parts, whether or not for vehicular use. Excluded establishments from this NAICS group include those primarily involved in:

  – Manufacturing diesel engines and parts for motor vehicles (33361, Engine, Turbine and Power Transmission Equipment Manufacturing);

  – Manufacturing electrical fuel pumps (33632, Motor Vehicle Electrical and Electronic Equipment Manufacturing); and

  – Manufacturing transmission and power train equipment (33635, Motor Vehicle Transmission and Power Train Parts Manufacturing).

- Motor Vehicle Electrical and Electronic Equipment Manufacturing (NAICS 33632).

  This industry comprises establishments primarily engaged in manufacturing and rebuilding electrical and electronic equipment for motor vehicles and internal combustion engines. Excluded establishments from this NAICS group include those primarily involved in:

  – Manufacturing sealed-beam lamps (33511, Electric Lamp Bulb and Parts Manufacturing); and

  – Manufacturing batteries (33591, Battery Manufacturing).

- Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing (NAICS 33633).

  This industry comprises establishments primarily engaged in manufacturing motor vehicle steering mechanisms and suspension components, except springs. The rebuilding, on a factory basis, of rack and pinion steering assemblies is included. Excluded establishments from this NAICS group include those primarily involved in:

  – Manufacturing motor vehicle coil and leaf springs (33261, Spring and Wire Product Manufacturing).

- Motor Vehicle Brake System Manufacturing (NAICS 33634).

[42] http://stds.statcan.ca/english/naics/2002/naics02-class-search.asp?criteria=3363 (accessed December 20, 2005)

This industry comprises establishments primarily engaged in manufacturing motor vehicle brake systems and related components.

- Motor Vehicle Transmission and Power Train Parts Manufacturing (NAICS 33635).

  This industry comprises establishments primarily engaged in manufacturing and rebuilding motor vehicle transmission and power train parts.

APPENDIX C

AGREEMENTS FOR TOXIC REDUCTION AND SUBSTANCES OF CONCERN

APPENDIX C – AGREEMENTS FOR TOXIC REDUCTION AND SUBSTANCES OF CONCERN

Following is the list of agreements and programs identified by the Ontario MOE to be of particular concern. These agreements and programs were the impetus behind the development of this series of BMP documents.

- The 2002 Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem (COA), which identifies the goal of virtual elimination Tier I substances, reductions of Tier II substances and virtual elimination of 17 PAHs.
- The *Canadian Environmental Protection Act*, 1999 (CEPA).
- The 1997 Bi-National Toxics Strategy (BNTS), signed by Environment Canada and the USEPA.
- The Ontario government's commitment to implement recommendation #32 of Commissioner O'Connor's Report on the Walkerton Inquiry Part 2 to support major wastewater plant operators to identify practical methods to reduce or remove heavy metals and priority organics that are not removed by conventional treatment.

The following hazardous substances are subject of the agreements identified above and/ or subject of potential concern due to environmental and human health effects. (Note that not all of these substances have been addressed in the series of BMP documents for the six sectors.)

Table C.1 Substances of Concern Subject to Agreements

Substance	COA	CEPA	BNTS
1,4-dichlorobenzene	Tier II	n/a	Level II
3,3-dichlorobenzidine	Tier II	Schedule 1	Level II
alkyl-lead	Tier I	n/a	Level I
cadmium	Tier II	n/a	Level II
chromium	n/a	n/a	n/a
copper	n/a	n/a	n/a
dioxins and furans	Tier I	n/a	Level I
hexachlorobenzene	Tier I	Schedule 1	Level I
hexachlorobutadiene/hexachloro-1,3-butadiene	n/a	Schedule 1	Level II
hexachlorocyclohexane	Tier II	n/a	Level II
lead	n/a	Schedule 1	n/a
mercury	Tier I	Schedule 1	Level I
nonylphenol and ethoxylates	n/a	Schedule 1	n/a
octachlorostyrene	Tier I	n/a	Level I
polynuclear aromatic hydrocarbons (PAHs)	Tier II	Schedule 1	Level II
pentachlorophenol	Tier II	n/a	Level II
vinyl chloride	n/a	Schedule 1	n/a
zinc	n/a	n/a	n/a

APPENDIX D

CASE STUDY EXAMPLES DEMONSTRATING BENEFITS OF P2 MEASURES

APPENDIX D: CASE STUDY EXAMPLES DEMONSTRATING BENEFITS OF P2 MEASURES

The following case studies pertain to facilities among the six industrial sectors of interest for this BMP series. The case studies demonstrate the reduction effectiveness of P2 measures for specific applications while, at the same time, demonstrating the benefits of undertaking P2 measures. Reference information is provided for further investigation of the case study experience.

Proponents are encouraged to document their experience with P2 measures for publication as case studies. Several organizations recognize leadership in Canada in the area of P2 implementation, including the Canadian Council of Ministers of the Environment (CCME).

Case Study for P2 Measure: Material Substitution

Hafner Inc., with four facilities in Granby, Quebec, is the largest Canadian manufacturer of furniture fabric and stretch knitted fabric. Material substitution enabled the company to reduce its nonylphenol and nonylphenol ethoxylated derivatives load from 6,800 kilograms in 2001 to 68 kilograms in 2003. The chemical oxygen demand (COD) of the wastewater was reduced from 210,000 kilograms per year to 110,000 kilograms per year. The reduction in COD reduced the annual effluent disposal costs by $15,000. For further information, see the following:

Environment Canada's Pollution Prevention Success Stories website: Hafner Inc.
http://www.ec.gc.ca/pp/en/storyoutput.cfm?storyid=111

Case Study for P2 Measure: Process Modification

Monsanto Company, Muscatine, Iowa Plant, is a large agricultural herbicide manufacturing facility. Through internal recycling and process modifications, the facility reduced wastewater biochemical oxygen demand (BOD) loading by 97 %. For further information, see the following:

U.S. Environmental Protection Agency's National Environmental Performance Track website: Performance Track Case Study Monsanto Company – Muscatine, Iowa Plant
http://www.epa.gov/performancetrack/tools/casestudies/MonsantoCaseStudy.pdf

Case Study for P2 Measure: Operating Procedures and Housekeeping

Hendersons Automotive Group, a major supplier of seating components, has implemented several good housekeeping measures which have helped raise pollution prevention consciousness among the 180 employees at the company's Melrose Park plant in South Australia. Cleaner production measures introduced have resulted in annual savings of $270,000. The measures cost a total of $309,000 and paid for themselves in only 18 months after implementation. For more information, see the following:

Australian Department of the Environment and Heritage's Eco-Efficiency and Cleaner Production website: Hendersons Automotive Group Cleaner Production – Continuous Improvement Programs
http://www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/hendersons.html

Case Study for P2 Measure: Process Modification

Monroe Australia is a leading Adelaide-based manufacturer of shock absorbers and strut suspension units for the automotive industry. The company has implemented a major waste minimization strategy that has enabled it to process liquid waste, reduce water usage, reduce chemical and waste disposal costs, and eliminate pollution. It installed new equipment which treats wastewater to remove emulsified fats and oils, grease, heavy metals and all forms of suspended, colloidal and some dissolved solids. Monroe's mains water usage has been reduced by over 10 ML per year; wastewater discharge to sewer has been reduced by 50 percent. The new technology has produced a savings of $250,000 per year with total outlay of $530,000 for a payback period of approximately two years. For more information, see the following:

Australian Department of the Environment and Heritage's Eco-Efficiency and Cleaner Production website: Monroe Australia Pty Ltd Cleaner Production – Waste Minimisation Strategy
http://www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/monroe.html

Case Study for P2 Measure: Process Modification and Operating Procedures

Specific Plating is a small metal finishing company where parts are plated with metals such as copper, nickel, zinc, silver, and gold. Specific Planting has dramatically reduced its sewer discharges of copper and nickel through pollution prevention efforts including both modifications of industrial processes and improved waste handling and treatment techniques. After the completion of the P2 projects, a reduction of approximately 88% for copper discharges and 85% for nickel discharges was achieved. Wastewater discharge flow has been reduced 27% and off-site sludge disposal has been reduced 53%.

Installation of equipment or changes in operating procedures required an investment of $63,000. Annual savings of $30,000 was realized with the payback period ranging from 1.5 years to just under 3 years. For more information, see the following:

City of Palo Alto's website: Pollution Prevention at Specific Plating Company
http://www.city.palo-alto.ca.us/public-works/documents/cb-specific.pdf